



The Blast Furnace *and* Steel Plant

Published the first of each month by the National Iron and Steel Publishing Co.

Main Office — Thaw Building, 108 Smithfield Street, Pittsburgh.

DISTRICT OFFICES — NEW YORK AND CHICAGO.

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Subscription Price:—In the United States, \$1 per year; Canada, \$1.50; all other countries, \$2. Single Copy, 15 Cents.
Entered as second-class mail matter at Pittsburgh, Pa., under the Act of Congress, March 3, 1879.

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DECEMBER, 1918.

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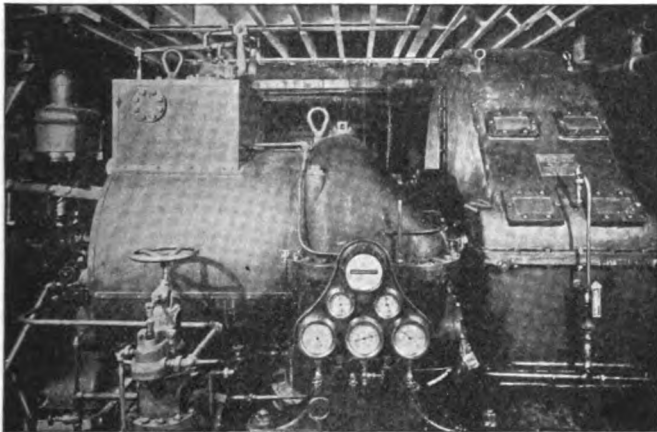
The Blast Furnace *and* Steel Plant

Steam Turbine Progress and Possibilities

Higher Boiler Pressures—Intermediate Steam Reheating in Large Multiple-Cylinder Machines—Feed Water Heating—Greater Economy to Be Expected from Extended Use of Economizer.

Discussion of the general progress of turbine development in the past, is not complete without reference to the possibilities of the future. It is plain that with turbines of large size, which deliver to the switchboard 76 to 80 per cent of the theoretical energy available from the steam expanding between the limits specified, further improvements in the turbine itself will not materially raise this efficiency, and that further improvement in central station economies must be looked to from causes other than the steam

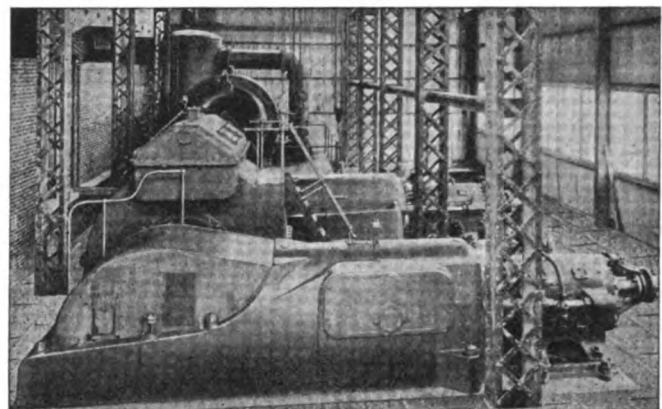
erated at 200 pounds. Doubtless, when operating under these conditions, the turbine will be of lower efficiency. The high pressure element will be less sufficient on account of the great density and the small volume of steam, and on the other hand the low-pressure elements will be less efficient because of the great amount of water precipitated by the steam expansion from the high pressure, introducing a brake in the turbine. However, it is reasonable to suppose that the turbine will avail itself of at least 50 per cent



1,700 H. P. 3,000 R. P. M. Westinghouse complete expansion steam turbine.

turbine. This is a subject of the greatest importance in view of the rapidly increasing cost of fuel and justifies considerably more capital expenditure for economizers and other plant apparatus which will reduce fuel cost.

Attention at the present time is being directed to employing higher boiler pressures; viz., pressures as high as 600 pounds. Today 200 pounds pressure, 200 degrees F., superheat is regarded as a more or less every day operating condition for large plants. Steam generated at 600 pounds pressure, having exactly the same heat content as that contained in 200 pounds pressure and 200 degrees F. superheat, will have a superheat of approximately 128 degrees F. This expanded to 29 inches of vacuum is theoretically capable of giving 13 per cent more energy than when gen-



3,000 H. P. 155 R. P. M. low pressure steam turbine.

of this 13 per cent possibility, producing a net saving of 6 or 7 per cent. What may be expected to be derived from higher pressures is exhibited in Figs. 1 and 2, plotted for various pressures.

Another source of improvement of performance in large multiple-cylinder machines may be obtained by intermediate reheating, the steam expanding from a high pressure and superheat through a high-pressure element to a pressure of say 40 pounds absolute, where nearly all the superheat has disappeared; the steam then being pressed through a separately-fired super-heater and raised to approximately its original temperature, thus giving a nearly dry cycle to the whole steam expansion. The addition of an intermediate reheater to such an installation would be expected to secure an improvement in total B.t.u

supplied, of 3 per cent. Until lately, however, the capital expense involved would hardly have been warranted.

Much more than formerly, attention is being given to the subject of feed water heating and means are available for providing a heat balance between the feed water heating system and the main turbine unit, valves being provided which will take steam from the turbine whenever there is a deficiency of auxiliary exhaust steam for heating feed water and take steam

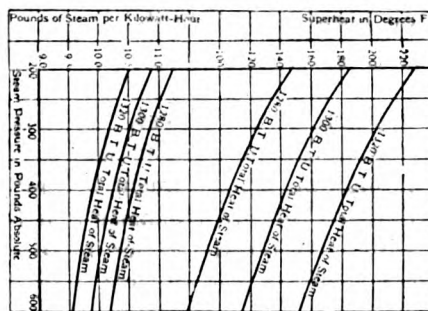


Fig. 1.

from the heating system when the feed water heater is incapable of condensing all of the exhaust steam from the auxiliaries. Valves are also available which, when the conditions demand, will take steam from a higher pressure stage of the turbine in one case and admit steam to a lower stage in the other.

A heat balance system has been proposed, employing electric motors for driving the auxiliary machines and these in turn operated by a special generating unit, the generator being driven both by a non-condensing steam turbine, an electric motor operated from the main busbars, the flow of steam to the turbine being controlled by the pressure in the exhaust and hence by the needs of the feed water heater. At times of excessive demands for feed water heating, the motor may give energy to the system and conversely when there is a small demand for steam for heating feed water, the energy for driving the auxiliaries will in part, come from the main units. The auxiliaries, being motor driven, have the advantage of reducing the general dirtiness, heat, and overcrowding to be found in the basements of many power plants on account of the steam and exhaust piping of the many small turbines. The general prejudice against electric motors for other auxiliaries would seem to be giving way in view of greater ruggedness of electric motors and the safety of their circuits. The heat energy actually required to operate the auxiliaries with such a system would be far less on account of the better performance of the large turbine unit as compared with the number of small non-condensing auxiliary turbines, in spite of the electrical losses involved.

Further economy may be expected by making more extended use of the economizer. Until lately it

has been considered difficult to operate economizers successfully if the feed water is admitted to them at temperature much below 200 degrees, because of corrosion of the surfaces and the condensation of tarry compounds from the fuel. It is probable that in the future economizers will operate well with the water entering them at 120 degrees or thereabouts, the water being heated to this temperature by a fewer number of steam-driven auxiliaries or by the employment of electrically-driven auxiliaries entirely and bleeding the main turbine at a stage where the pressure is commensurate with that temperature.

The present time is a very important period in the development of the steam turbine. A large number of big units have been built ranging in size from 25,000 to 60,000 kilowatts. Those built by the General Electric Company are of the impulse type, those by the Westinghouse Company entirely of the reaction type, and sometimes a combination of both types, where the complete expansion is carried out in a single cylinder. Of the Westinghouse machines, the increased reliability obtained by dividing the steam expansion in separate cylinder structures is recognized. Some have been arranged with the high and low-pressure cylinders arranged tandem fashion, driving a single generator. Others are arranged "cross compound," each turbine element driving a separate generator. The very largest sizes are of the three element design, comprising one high pressure turbine, with a low pressure on either side, each of the three elements having its separate generator.

Some of these units are now in operation, and within another year, a great many will be in service. Some of them will be tested for steam efficiency. All

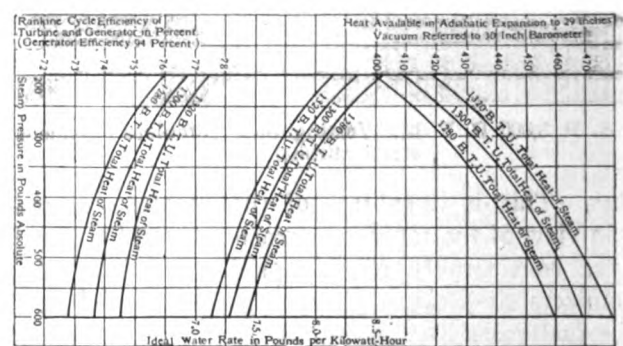
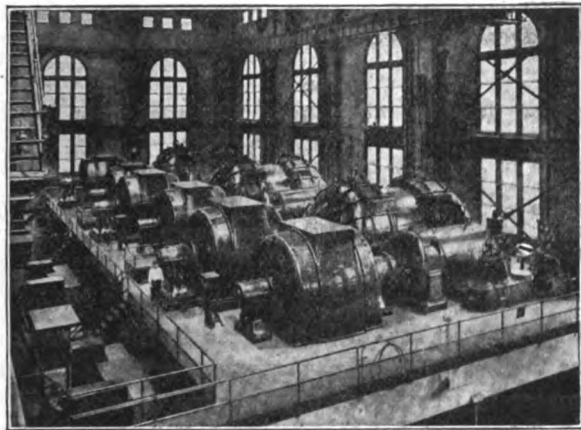


Fig. 2.

of them will give evidence as to their reliability of operation and accessibility for inspection and repairs. The multi-cylinder turbine certainly seems to have much to commend it, if there is anything in the thought that with increase in the capacity of the prime mover, there should be a corresponding increase in reliability. These very large units, if built in a single structure, impose grave problems of design, for as the structure becomes larger, the more likely it is to change shape under the varying tem-

peratures within its walls. Also, the hazard is introduced of using higher grade materials, to deal with higher stresses, with all the uncertainty which that question involves in the actual securing and testing of such materials, with absolute knowledge that the quality of the test specimen will be secured approximately in the finished piece.

We then have the increasingly imminent question of dealing with higher steam temperatures, which does not make the design of turbines any easier, as is



Cross Compound Turbines.

well proven in several recent instances. So, if we take advantage of the fact that in size alone resides an ability to achieve higher efficiency, then it would seem that the uncertainties of design and construction as regards heat stresses, as well as centrifugal stresses, can best be removed by introducing no new questions. Let us have the high efficiency that comes with large size, as being within well-tried practice, dealing with no special materials, avoiding widely differing temperatures within the same structure, keeping the high temperatures within the relatively small high pressure element, and be ready, also, for the still higher temperatures of the future. The multi-cylinder arrangement occupies more room, measured in the width of the unit, but less in length; however the turbine room space in this respect is not a problem in most stations. They have the advantage, previously pointed out, that the turbine elements are sensible of being operated separately in the event of derangement of either one of them. Automatic apparatus is provided when demanded, for any two of the three turbine elements continuing to carry load, should the one be taken out of service, either by the opening of the circuit-breaker or by tripping the emergency stop. The compound unit costs more money, but not prohibitively more, if the construction behind its adoption is justified by experience. In view of the present power house costs, there would seem to be no economic need of reducing the cost of the turbine units below the amount required to make them as nearly perfect as possible. It is hoped that

the time is not far distant when the turbine designer will not have to initiate quite so much as he has in the past; that on the operating side the engineers will test their turbines more generally and will know precisely what results they give in steam consumption, and will take a stronger position respecting the mechanical features of design, details of operating convenience, etc., much as they used to when they dealt with the subject of Corliss engines, and recognize and give consideration to better detail design of not only the turbine itself, but its appurtenances.

From all that has been said it is plain that the progress in the construction of turbines has not been to reduce intrinsic cost. The increased reliability, while sometimes secured by more skillful design, and at even a reduction of cost, generally however, involves a greater cost. The higher operating conditions: pressure, superheat and vacuum, each involve greater expense. The higher vacuum calls for larger low-pressure blade arrears, as well as an increased number of turbine elements. The higher pressures and superheat both involve more turbine elements, and also preclude the use of cast iron for the high pressure portions, adding materially to the cost of gears, etc. Competition calling for the highest performance, has brought about the employment of higher design co-efficients which introduce still another element of increased cost. The increase in rotational speed for a given size machine is about the only item besides improved manufacturing processes that have enabled manufacturing costs to be reduced.

In spite of this, the price (under pre-war conditions) of large turbine generating units has been reduced to approximately 40 per cent of the cost of the earlier large turbines of 5,000 kilowatts or thereabouts. The efficiency ratio has been increased in this size approximately 8 per cent. Considering the larger sizes the cost per kilowatt is further reduced and efficiency ratios have been improved 12 per cent. Actual heat consumption of B.t.u. supplied at the throttle has shown a reduction of 24 per cent between the 7,500-kilowatt turbine of 1905 and the Interborough turbine of 1914.

To make similar comparison between a modern large turbine installation and the best performance of reciprocating engines, assume:

	Turbines	Engine
Initial cost per kw of the generating units.	\$ 8.00	\$40.00
Fixed charges, per cent.	.15	.15
Pounds steam per kw-hour.	.11	.17
Cost of steam per 1000 lbs. at 220 lbs. 150 degrees supht, 175 lbs. dry sat.	.15	.14
Load factor	.75	.75
Cost of foundations per kw.	.50	2.50
Cost of condensers per kw.	3.50	2.50
Cost of engine room personnel, not including executive administration, pr. kw. pr. yr	0.61	1.57
Oil and engine room supplies per kw. yr.	.10	1.34
Total cost per kw. per year.	\$13.34	\$25.29

Slag Temperature Influence on Refractories

Investigation Carried Out for the Purpose of Determining the Action of Various Slags at Different Temperatures on Several Standard Brands of Fire Brick.

By **RAYMOND M. HOWE.**

Mellon Institute.

During the present period of intense industrial activity, the linings of the various furnaces have played a very important role in determining their capacities. In some cases the firebrick or special shapes have given long continuous service, while in other cases the results have not been as satisfactory. As a result, there has been some contention between the consumers and manufacturers of firebrick as to the relative merits of this product, the consumers often claiming that it is not of the pre-war standard and the manufacturers maintaining that it is of equal quality. The latter maintain that the shorter life of refractories, when encountered, is often due to the more severe duty which is imposed upon their product during the struggle for an ever-increasing output of metals.

The work here presented was carried out for the purpose of determining the action of various slags at different temperatures on several standard brands of firebrick. The data secured would therefore appear to bear directly upon the question at issue, for it is well-known that a common means of increasing production consists of increasing the working temperature.

The general plan was to secure bricks of recognized quality and to test the action of several slags upon them at different temperatures. The method used for determining this action was essentially the same as is used at the Carnegie Steel Company.

Work done at that laboratory has shown that if a brick is heated to a definite temperature and 35 grams of slag are placed in a cavity at that temperature and are allowed to act for two hours, valuable information can be secured.

Before adopting their method certain points were checked pertaining chiefly to the influence of the time of action of, and the quantity of slag used, upon the results secured. Tests were made in which the time and slag were trebled, but this procedure failed to produce a more pronounced action.

In reporting the results the total cross-section of the slag saturated area was first measured by means of a planimeter. The area of the original cavity was then subtracted from this. The difference represented the area of the section which had been penetrated by

the slag. This area when divided by the linear surface of contact gave a value which represented the square inches of penetration per inch of contact.

Table I.

Influence of time and quantity of slag used upon results secured from slag tests.

Penetration of 35 grams of slag in two hours.....	.64
Penetration of 35 grams of slag in four hours.....	.68
Penetration of 35 grams of slag in six hours.....	.64
Penetration of 105 grams of slag in two hours.....	.76
Penetration of 105 grams of slag in four hours.....	.72

The results given in Table I confirmed those reported by Nesbitt and Bell and lead to the same conclusions, i. e., when a brick having a cavity $2\frac{1}{2}$ inches in diameter is treated with 35 grams of slag and it is allowed to react for two hours satisfactory results are obtained. In the preceding work 35 grams of slag reacting for two hours resulted in a penetration value of 0.64. When the severity of this test was increased 600 per cent, the penetration factor increased but 12.5 per cent.

Method of Procedure.

In view of this preliminary work, the following definite method of procedure was adopted.

Table II.

Slag	Blast Fur.	Heating Fur.	Basic Open Hearth	Acid Open Hearth	Zinc	Copper
Silica	37.32	34.16	18.42	46.48	34.30	28.20
Alumina	13.21	6.13	3.85	5.45	14.74	2.20
Iron	1.62	43.60	14.55	29.30	21.00	2.10
Lime	42.20	1.30	44.10	2.16	2.33	2.51
Magnesia	2.35	.65	6.32	.00	7.07	2.14
Manganese	1.11	.55	5.09	9.08	6.77	.00
Sulphur	1.20	.27	.42	.38	5.88	.14
Phosphorus	.00	.02	.58	.00	.02	.24
Copper	.00	.00	.00	.00	1.28	58.21
Zinc	.00	.00	.00	.00	8.20	.00
Melting pt ..	1220°C.	1050°C.	1275°C.	1400°C.	1025°C.	1020°C.

The test bricks, each having two cavities $2\frac{1}{2}$ inches in diameter by $\frac{1}{2}$ inch in depth, were heated slowly to the temperature at which the test was to be made. This temperature was held for $1\frac{1}{2}$ hours. Thirty-five grams of slag were then introduced and were allowed to react at this temperature for 2 hours. The bricks were then allowed to cool, were cut through the center of the cavities, and the penetration was noted in the manner previously described.

Six slags, which were secured from the Carnegie Steel Company's laboratory, were used during the tests. Their analyses and fusion points are given in

Paper read before the Refractories Manufacturers Association.

Table II. The three bricks used are designated by A, B and C.

Experimental Data.

By following method already described and varying the brick, the slag and the temperature, one at a time, the following average results were secured.

Table III.

Effect of various temperatures upon the penetrating power of heating furnace slag (m.p. 1050°C.)

Brick	Temperature of Test.			
	1150°C.	1250°C.	1350°C.	1450°C.
Type A.....	.04	.09	.15	.34
Type B.....	.02	.05	.11	.79
Type C.....	.07	.10	.24	.78

Table IV.

Effect of various temperatures upon the penetrating power of blast furnace slag (m.p. 1220°C.)

Brick	Temperature of Test.		
	1250°C.	1350°C.	1450°C.
Type A.....	.03	.08	.14
Type B.....	.00	.11	.17
Type C.....	.07	.12	.17

Table V.

Effect of various temperatures upon the penetrating power of zinc slag (m.p. 1025°C.)

Brick	Temperature of Test.			
	1150°C.	1250°C.	1350°C.	1450°C.
Type A.....	.03	.13	.28	.19
Type B.....	.04	.16	.29	.32
Type C.....	.05	.24	.33	.43

Table VI.

Effect of various temperatures upon the penetrating power of basic open hearth slag (m.p. 1275°C.)

Brick	Temperature of Test.	
	1350°C.	1450°C.
Type A.....	.58	.73
Type B.....	.29	.33
Type C.....	.44	.55

Table VII.

Penetration of acid open hearth slag (m.p. 1400°C.) at 1450°C.

Brick	Penetration
Type A.....	.24
Type B.....	.33
Type C.....	.57

Table VIII.

Penetration of copper slag (m.p. 1020°C.) at two temperatures

Brick	Temperature of Test.	
	1150°C.	1250°C.
Type A.....	.46	.65
Type B.....	.36	.57
Type C.....	.52	.62

In each case the slag penetrated more deeply into the brick at higher temperatures. In several cases an increase of 100°C., or less than 10.0 per cent, resulted in nearly doubling the penetration.

This increased penetration has several effects in actual practice. One effect concerns the strength of the brick itself. It is a known fact that bricks when saturated with slag are not so strong at high temperatures as when they are free from slag. This decreases their ability to sustain the weight of the other parts of the furnace.

The refractoriness of the lining is also decreased when it becomes soaked with slag.

The lining is also subjected to more severe chemi-

cal action. This action takes place rather slowly in many cases, but rapidly in others. In any event, the action takes place sooner when the slag forces its way further into the inner portions of the lining. Being more active at higher temperatures, its solvent power is also increased.

In view of these tests, it appears very much as if the relation of output and the life of the lining is similar to the rate of driving and the life of an automobile. Cars which operate successfully for 50,000 miles when driven at the rate of 20 miles per hour give much less service when driven 40 miles per hour. These same cars when subjected to the gruelling ordeal of a stock car race often fail to complete the first 100 miles.

Such conditions are constantly encountered when any product is driven to its limit. Such being the case, it is not fair to compare the lives of furnace linings on the daily basis. Neither is it fair to compare them on the tonnage basis, when one furnace is worked at moderate and another at maximum capacity. Under conditions occurring with increased output, they must be compared according to a sliding scale. If a furnace is operated under such conditions that the daily output of metal is increased 50.0 per cent, it cannot be expected to last as long, or even two-thirds as long (during which time equal tonnage would have been secured), but from one-third to one-half as long. The consumer must realize this and balance his costs under normal production against those under increased production. If the balance is in favor of conditions of increased production, he must, if he uses the most suitable material, expect to encounter continued shorter service from linings.

COAL ZONING SYSTEM.

Estimates made earlier in the fuel year, that approximately 60,000,000 car-miles would be saved in the coal year through the operation of the zone system for the distribution of bituminous coal, are being fully realized.

This system, made possible through the close coöperation of the United States Railroad Administration with the Fuel Administration, has had a large share in bringing the nation's supply of bituminous coal to its present proportions, which, with patriotic economy, will be sufficient for the winter's requirements.

This method of distribution was established so that the coal supply of all sections of the country should normally be derived from mines relatively near, thus preventing abnormal and wasteful transportation movements, and insuring more equal distribution of cars to the mines and the more steady employment of mine labor.

Early estimates were that the movement of bituminous coal affected by the zone system would involve about 300,000,000 tons, or 60 per cent of the total production.

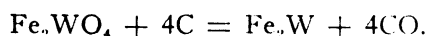
Electric Furnace Data for Ferro-Tungsten

Data and Description of Ferrotungsten Production—Smelting of Ferberite Concentrate—Ferrotungsten Containing Less Than One Per Cent Carbon Can Be Made in a Single Melting Operation.

By ROBERT M. KENNEY.

Tungsten is the leading alloy metal used in the manufacture of high-speed steel. Probably about half of the consumption is used in the form of ferrotungsten, the remainder being tungsten metal. Colorado has supplied a large part of the tungsten used in steel manufacture, but is gradually being surpassed by California, where the large scheelite deposits can produce tungsten considerably cheaper. Ferberite, found in Boulder County, Col., is one of the most favorable forms of tungsten for production of ferrotungsten, containing both iron and tungsten in the proper proportion to yield 70 to 80 per cent ferrotungsten. At present, three electric-furnace plants in Colorado are making or have made ferrotungsten. The standard grade produced by the Ferro Alloy Company contains 75 per cent tungsten, 0.8 carbon, 0.4 silicon, 0.5 manganese, 0.01 sulphur, 0.02 per cent phosphorus. The Tungsten Products Company makes about the same grade of product, except that the carbon is kept below 0.5 per cent, and the tungsten runs as high as 85 per cent. The product of this company is probably the highest-grade and the purest ferrotungsten made in this country. Ferrotungsten has a high density, fine gray fracture, and is not crystalline—the higher the carbon, the coarser the fracture. The carbon in ferrotungsten occurs as the double carbide, $\text{Fe}_3\text{C.W}_2\text{C}$.

One method commonly employed for production of ferrotungsten is reduction of ferberite or some other concentrate in the electric furnace, with carbon as a reducing agent, followed by a subsequent refining and decarburization. Reduction with carbon takes place according to the following reaction:



Theoretically, the product would contain 62.3 per cent tungsten, but, owing to the variation in iron in the ferberite, and to the fact that tungsten reduces from ferberite, in the electric furnace, before the iron comes down, a considerable part of the iron passes into the slag, so that the alloy contains about 70 per cent tungsten. The slag may contain as high as 8 per cent FeO , but less than 1 per cent. WO_3 . Theoretically, the reduction of 100 parts of alloy from 122 parts of ferberite requires 16 parts of carbon, but

practically about 25 per cent excess of carbon is charged. Small amounts of lime and fluorspar are used to flux the silica. Operating in this manner, with an excess of carbon, a product is made containing 3 per cent carbon, 70 per cent tungsten, 0.05 per cent phosphorus, and 0.01 per cent sulphur; the slag contains below 1 per cent. WO_3 . If desired, this product can be tapped from the furnace, but, as its behavior is erratic, it is preferable to allow the metal to collect in the bottom of the furnace, forming, in a 150-kw. furnace, a button about 3 ft. in diameter, 6 in. thick, and weighing 1,000 to 1,200 lbs.; the slag is poured off by tilting as it fills the furnace.

The concentrate used in the runs given in Tables 1 and 2 contained WO_3 , 60.36 per cent; iron, 22.0; SiO_2 , 8.0; manganese, 0.5; sulphur, 0.35; phosphorus, 0.05 per cent. The analysis of the coke was: fixed carbon, 81.8; volatile, 1.70; ash, 16.5; sulphur, 0.60; phosphorus, 0.092 per cent. The lime contained: CaO , 89.0; MgO , 0.73; SiO_2 , 1.1; sulphur, 0.41; phosphorous, 0.072 per cent. The fluorspar contained 80.0 per cent CaF_2 .

Smelting of Ferberite Concentrate.

A typical operation is conducted as follows: The initial charge is 65 lbs. of a mixture composed of 200 lbs. concentrate, 42 lbs. coke, 56 lbs. lime, 6 lbs. fluorspar. Three more 65-lb. charges are added at intervals of $\frac{1}{2}$ hr., and at $2\frac{1}{2}$ hrs. from the start, the furnace is tilted and the slag poured. This cycle is repeated until a 1,200-lb. button has been formed, requiring 24 to 36 hrs. The furnace is allowed to cool, is torn down, and the button of metal removed. This is then cleaned and broken up, the breaking process being somewhat difficult with a 3 per cent carbon alloy.

The results of smelting ferberite concentrate to produce a crude ferrotungsten are given in Table 1. In this operation there is practically no loss of tungsten in the slag, the slags averaging 0.72 per cent tungsten. Considerable mechanical loss is shown in these runs, but this occurs mainly in dust, when cleaning and breaking the button, and is recovered by melting. The total loss of tungsten in the smelting operation does not exceed 5 per cent.

From paper read before the A. I. M. E. meeting.

Table 1—Smelting of Ferberite Concentrate.

	1	2	3	4	5	6	7	8
Charge:								
Concentrate, lb.	1,200	1,800	1,600	1,600	2,275	3,150	2,950	3,100
Coke, lb.	252	380	330	330	476	662	662	648
Fluorspar, lb.	96	180	128	130	62	96	90	120
Lime, lb.	336	500	436	436	628	872	810	855
Ferrotungsten:								
Tungsten, %	71.71	71.35	67.9	68.2				
Carbon, %	1.01	1.7	1.03	1.09				
Sulphur, %	0.078	0.10	0.048	0.068				
Phosphorus, %	0.081	0.112	0.065	0.11				
Slag:								
Tungsten, %	0.56	0.80	0.90	1.26	0.20	0.88	0.35	0.39
Weight ferrotungsten, in button, lb.	731	982	847	908	954	1,884	1,490	1,971
Weight ferrotungsten, poured, lb.		122						
Weight, slag, lb.	588	1,020	510	1,121	1,960	1,612	1,200	2,613
Length run, hr.	19.33	26.17	20.17	22.0	36.0	40.5	44.0	48.0
Power on, hr.	17.33	21.08	18.0	19.42	34.83	38.83	42.5	46.33
Tungsten lost in slag, %	0.57	0.95	0.63	1.96	0.36	0.94	0.20	0.66
Tungsten lost mechanically, %*	10.23	11.05	19.37	11.84				
Tungsten recovered, %	80.2	87.4	80.0	86.2				

* Most of this is recovered in dust.

Note—The current consumption was 130 kw. at 95 volts.

Refining Ferrotungsten.

The crude metal, broken to about 6 in. size, is re-

averaged 1.2 per cent carbon. All of the slag from the refining process, averaging about 10 per cent tungsten, is re-treated for ferrotungsten, so that there is no loss in refining, except a slag loss of less than 1 per cent, and a mechanical loss. By smelting this slag, ferrotungsten was produced which contained tungsten, 79.1; carbon, 2.40; sulphur, 0.01; phosphorus, 0.02 per cent; the slag from this operation contained 0.95 per cent tungsten.

Ferrotungsten is one of the easiest ferro-alloys to manufacture, except for the fact that it must be made in a knock-down furnace, due to the high melting point of the alloy, about 2,500° C. Metallurgically it is simple, as tungsten has not so great a tendency to form carbides or to oxidize as have chromium and uranium. Ferrotungsten containing less than 1 per cent carbon can be made in a single smelting operation, by careful regulation of the carbon in the charge, and the use of an acid slag. The disadvantage of this

Table 2—Refining Ferrotungsten.

	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Charge:														
Ferrotungsten, lb.	1,400	1,200	800	1,835	1,680	1,160	1,190	1,050	1,200	1,200	1,200	1,200	1,350	1,500
Tungsten concentrate, lb.	448	480	320	720	674	462	476	420	520	670	600	675	750	825
Fluorspar, lb.	140	120	80	180	141	96	96	84	96	108	96	10	108	120
Ferrotungsten:														
Carbon, in button, %	0.84	0.88	0.90	0.68	0.71	0.73	0.88	0.75	0.65	0.66	0.91	0.66	0.97	0.57
Carbon, in poured, %	1.37	0.95	1.27	1.32	1.22	....	....	....	....	1.02	1.59	1.50	....	0.63
Slag:														
Tungsten, %	5.21	5.21	5.21	5.21	9.50	17.18	....	5.54	5.54	....	....	....	....	....
Concentrate charged per 100 lbs. ferrotungsten	32.00	40.00	40.00	39.25	40.25	39.75	40.20	40.0	43.4	55.8	50.0	56.3	55.6	55.0
Weight ferrotungsten in button, lb.	939	1,232	400	1,868	1,424	814	727	913	922	1,217	1,278	1,234	1,535	1,672
Weight ferrotungsten poured, lb. ....	....	....	720	186	335	345	70	....	138	101	62	....	266	407
Weight slag, lb.	393	497	534	812	568	544	412	373	495	543	418	576	470	571
Length run, hr.	22.66	21.33	19.5	17.33	34.83	33.75	26.0	33.5	29.5	34.5	35.33	32.33	33.75	37.33
Power on, hr.	22.00	20.83	19.0	16.17	33.83	32.66	25.45	31.83	28.75	33.33	34.5	31.5	33.0	36.5

Note—The power consumption was 130 kw. at 95 volts.

fined as follows: A charge of 150 lbs. metal and 75 lbs. ferberite concentrate is smelted for ½ hr., when 12 lbs. fluorspar is added. After another 3 hrs. the slag is poured, and a fresh charge is started. The process is continued for from 36 to 48 hrs. until a button weighing 1,500 lbs. has formed in the furnace, a larger button being permissible because the low-carbon alloy is easier to break. The furnace is allowed to cool, is torn down, and the button of metal removed, cleaned, and broken. The refined button forms very compactly, and is free from slag. The refining has reduced the carbon from 3 to 0.8 per cent, reduced the phosphorus from 0.05 to 0.01 per cent, left the sulphur the same, and increased the tungsten from 70 to 75 per cent. The refining slag contains 5 to 20 per cent tungsten, and is resmelted in a special run.

Table 2 gives data on the refining of crude ferrotungsten containing 2 to 3 per cent carbon, to yield a product with less than 1 per cent carbon.

During these runs a considerable quantity of ferrotungsten was poured from the furnace with the slag. While the metal obtained in button form contained less than 0.9 per cent carbon, the poured metal

method is that the product is less pure, and the slag loss is considerably higher; the metal will contain much higher phosphorus and sulphur, and the total loss of tungsten may be 25 per cent as compared with 10 to 15 per cent by the two-stage process.

Nearly every manufacturer of ferrotungsten has tried to tap it from the furnace, but none has continued the practice. If the tungsten is reduced to 55 to 60 per cent, the alloy can be tapped, even with carbon as low as 0.2 per cent. With tungsten at 70 per cent, metal containing 0.9 per cent carbon has run out while pouring slag, but generally any metal which comes out with the slag will contain 1.25 per cent carbon. The irregularity of tapping operations with ferrotungsten has prevented the adoption of that method, because if part of the metal must be retained in the furnace, it is cheaper to keep it all there. Furthermore, the poured metal is very hard to break.

In ferrotungsten production it is essential to maintain regularity of charging, as this is the only way to insure homogeneous composition of the metal, since the button is not melted throughout.

Waste Heat from Open Hearth Furnaces

Analysis of Producer Gas Supplied to Furnace—Theoretical Principles Governing the Operation of Waste Heat Boilers—Suggestions Concerning the Layout of the Plant, Boiler Setting, Etc.

By THOMAS B. MACKENZIE.

PART II.

A typical analysis of the producer gas supplied to the furnaces during the previous tests is:—CO₂, 8.2 per cent.; CO, 20.8 per cent.; CH₄, 3.4 per cent.; H₂, 13.0 per cent.; N₂, 54.6 per cent. From which the amount of air and volume of products of combustion, with the theoretical amount of air required for complete combustion, can be calculated. The result is shown in Table XI.

Table XI.

Gas, cub. ft. per cub. ft.	Air for complete combustion	Products of combustion.		
		CO ₂	H ₂ O	N.
CO ₂ : 0.082	—	0.082	—	—
CO : 0.208	O : 0.104	0.208	—	—
CH ₄ : 0.034	O ₂ : 0.068	0.034	0.068	—
H ₂ : 0.130	O ₂ : 0.065	—	0.130	—
N ₂ : 0.546	N ₂ : 0.902	—	—	1.448
1.000	1.139	0.324	0.198	1.448

1.139 volumes of air are therefore required for the theoretical combustion of 1 cu. ft. of producer gas, and will yield 1.97 cu. ft. of products of combustion all reduced to s.t.p. A typical analysis of the waste gases entering boiler, estimated on a dry sample is:—CO₂, 11.2 per cent.; O₂, 7.2 per cent.; N₂, 81.6 per cent. Replacing the water vapour and separating from the N₂ that entering with the excess air, the volumes and percentages are in 1 cu. ft. of the products as in Table XII.

Table XII.

Gas.	Cub. ft. per cub. ft.	Per cent.
CO ₂	0.1127	11.27
H ₂ O	0.0688	6.88
N ₂	0.4996	49.96
Excess air	0.3189	31.89
	1.0000	100.000

The total volume of the products of combustion are with this amount of excess air 2.89 times that of the producer gas when they are at the same temperature and pressure. The mean specific heats of the gases in lb. calories per cu. ft. at s.t.p. have been calculated by the following Malard-le-Chatelier formulae:—

$$\begin{aligned} \text{CO}_2 &= 0.023 + 0.000014t^\circ \text{ C.} \\ \text{H}_2\text{O} &= 0.021 + 0.000009t^\circ \text{ C.} \\ \text{O}_2 \text{ and N}_2 &= 0.0189 + 0.0000017t^\circ \text{ C.} \end{aligned}$$

To facilitate the use of these formulae the diagram in Fig. 2 is appended, on which the temperatures of the gases and quantities of heat in lb. calories are

plotted as co-ordinates. The curved lines give the values for the various gases named. To use the diagram all that is necessary is to multiply the fraction of a cubic foot of the particular gas in 1 cu. ft. of the mixture by the value of the heat contents on the vertical scale opposite the point where a vertical from the temperature cuts the curve of the gas required, when the sum of the products will give the heat contents of the mixture in lb. calories per cu. ft. The calorific value of the producer gas is 78.91 lb. calories per cu. ft., and its volume about 150,000 cu. ft. at s.t.p. per ton of fuel.

The furnace, when the whole volume of gas passed through the boiler, was delivering 950,000 ft.³ of

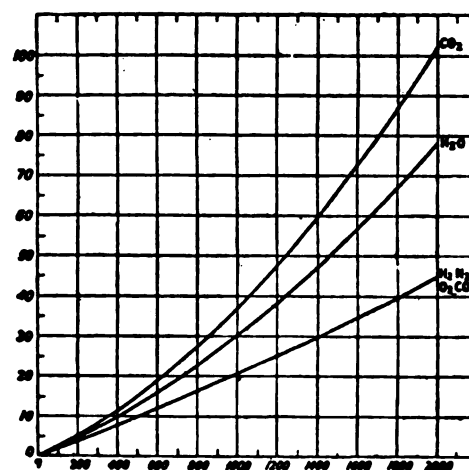


Fig. 2—Heat contents of gases at varying temperature and constant pressure in Lb.-Calories per cubic Ft.

products per hour at s.t.p., and was producing ingots at the rate of 5.94 tons per hour; its fuel consumption was therefore:—

$$\frac{950,000 \text{ ft.}^3 \text{ per hour}}{7,500 \text{ ft.}^3 \text{ per cwt.} \times 5.94 \times 2.89} = 7.377 \text{ cwt. per ton of ingots.}$$

As the furnace was working on cold-stock, and the fuel contains on an average 13.5 per cent ash and 9.7 per cent water, the result is fairly good.

Consideration may now be given to the theoretical principles which govern the operation of waste-heat boilers, making use of the data which have been observed in connection with the above tests to determine the constants, to enable formulae to be constructed for fixing area of heating surface, etc. Let—

Φ_1 = Quantity of heat per ft.² in products entering boiler.

Φ_2 = Quantity of heat per ft.² in products leaving boiler and entering economizer.

Φ_3 = Quantity of heat per ft.² in products leaving economizer.

*Paper read before British Iron and Steel Institute.

V = Volume of products per hour reduced to s.t.p.
 H_1 = Area of boiler heating surface in sq. ft.
 H_2 = Area of economizer heating surface in sq. ft.
 M_1 = Modulus of heat transmission through boiler H.S.
 M_2 = Modulus of heat transmission through economizer H.S.

The amount of heat transmitted through an element of heating surface dH , will be: $dH.M.\Phi$. The volume of products flowing past this place in an hour is V cub. ft., and the heat lost by it will be: $V.d\Phi$. When steady conditions have been attained, these expressions must be equal to each other, therefore:

$dH.M.\Phi = -V.d\Phi$, equal to:

$$\frac{dH}{d\Phi} = -\frac{V}{M} \cdot \frac{1}{\Phi} \quad \dots \quad (1)$$

Integrating (1) there is obtained:

$$H = -\frac{V}{M} \cdot \log \Phi + \text{const.} \quad \dots \quad (2)^*$$

To determine the constant, make $H = 0$, at which place the entrance to the boiler, $\Phi = \Phi_1$ and the constant is:

$$\frac{V}{M} \cdot \log \Phi_1.$$

Taking the integral over the whole heating surface from the entrance where $\Phi = \Phi_1$, to the outlet when $\Phi = \Phi_2$, there is obtained the equation:

$$\frac{HM}{V} = \log \left\{ \frac{\Phi_1}{\Phi_2} \right\} \quad \dots \quad (3)$$

Having observed V , H , Φ_1 , and Φ_2 , the modulus M_1 can be obtained from the equation:

$$M_1 = \frac{V}{H} \cdot \log \left\{ \frac{\Phi_1}{\Phi_2} \right\} \quad \dots \quad (4)$$

Finally having found M_1 and fixed on the ratio $\frac{\Phi_1}{\Phi_2}$, the heating surface of any boiler to deal with V cu. ft. of products per hour can be calculated from the equation:

$$H = \frac{V}{M_1} \cdot \log \left\{ \frac{\Phi_1}{\Phi_2} \right\} \quad \dots \quad (5)$$

The same argument applies to the economizer except that M_1 , Φ_1 , and Φ_2 are substituted for M_2 , Φ_1 and Φ_2 .

The modulus for boiler M_1 and that for economizer M_2 have been calculated from the data furnished by the tests recorded above with the results shown in Table XIII.

In the case of the economizers the results are rather inconsistent. It is, however, interesting to note that in Test III., which gives the highest value of M_2 , the economizer was new and was being supplied with Loch Katrine water, which is ideal for boiler purposes.

*The logs are the Napierian or natural logarithms.

Table XIII.

Test	Boiler.			Economizer.		
	Φ_1 Lb. cal.	Φ_2 Lb. cal.	Φ_3 Lb. cal.	$\frac{\Phi_1}{\Phi_2}$ M_1	$\frac{\Phi_2}{\Phi_3}$ M_2	M_3
Exp.	10.75	5.19	3.40	2.07	170.4	1.53
I.	12.65	5.59	3.66	2.26	178.3	1.53
II.	8.87	4.73	3.73	1.88	172.8	1.27
III.	12.47	6.10	3.45	2.04	162.6	1.77
IV.	9.26	6.26	5.39	1.48	169.8	1.16

It will be noted that the modulus, in the case of the boilers, is fairly consistent, the average value being 170.8. If it be taken as 171, equation 5 can be put in the form:

$$\frac{\text{Vol of products pr hr at s.t.p.}}{171} \times \log \left\{ \frac{\Phi_1}{\Phi_2} \right\} = \frac{\text{Heat'g surface}}{\text{of boiler in sq ft}} \quad (6)$$

The next highest is the experimental one when the economizer was also new and supplied with Motherwell water, which is a fairly good water. The third highest, Test No. I., was also supplied with Motherwell water, but the economizer had been in use for some time, so that the pipes were probably somewhat scaled. The two lowest results, Tests II. and IV., were both fed with water from Kilbirnie Loch in Ayrshire, and the water is rather hard.

If the average of the three highest values be taken we obtain the value 213.2, or in round figures 210. Equation 5 can then be put in the form:—

$$\frac{\text{Volume of products per hour at s.t.p.}}{210} \times \log \left\{ \frac{\Phi_2}{\Phi_1} \right\} = \frac{\text{Heating surface of econ'r}}{\text{in sq. ft.}} \quad (7)$$

To enable the results of these equations to be found by inspection the diagram, Fig. 3, has been prepared, on which will be found a scale at the bottom left-hand side giving values of volume of products per hour; the diagonal lines above this scale give different values of the modulus M . To the right of these are another series of diagonal lines giving different values

of the ratio $\frac{\Phi_1}{\Phi_2}$ or $\frac{\Phi_2}{\Phi_3}$ as the case may be, whilst at

the top right-hand side is a scale from which the appropriate area of heating surface of boiler or economizer can be read off.

The method of using the diagram is to select on the scale of volumes the value which applies to the case, pass vertically upwards to where the line cuts the value chosen as the modulus, then horizontally across to the intersection of the line giving the value chosen for the ratio of heat contents, then vertically upwards to the scale of heating surfaces, when the value required will be found.

Consideration may now be given to the rate of heat transmission through the boiler-heating surface. This will depend on two factors:—(a) The difference of temperature between the average heat of the hot products in their passage through the boiler chamber and the water inside the boiler, constituting the heat

gradient through the thickness of the material forming the heating surface. (b) The speed of flow of the hot products over the heating surface.

It will be assumed, what is probably correct, that when the speed of flow is constant the rate or transmission through the heating surface of the boiler will vary directly as the heat gradient, and that when the heat gradient is constant the rate of transmission will vary directly as the speed of flow of the products. It will also be assumed that the figure obtained by dividing the average volume of products passing through the boiler chamber by the area of heating surface will be proportional, with boilers all of the same type, to the speed of flow. With these assumptions Table XIV. has been calculated.

logarithms to base 10 of P and T are plotted as co-ordinates the points will lie in a cluster through which a straight line can be drawn inclined to the horizontal at an angle whose tangent is 0.32 and which will cut the vertical axis at 2.017, from which the following equation can be derived:—

$$T = 104 \times (P)^{0.32} \quad (8)$$

This equation can be written—

$$\log_{10} T = 2.017 + 0.32 \log_{10} P \quad (9)$$

in which form it is easily solved with the aid of a table of logarithms.

Values of T have been calculated for the several tests recorded in the first section of this paper and tabulated in column 6 of Table XIV. against the

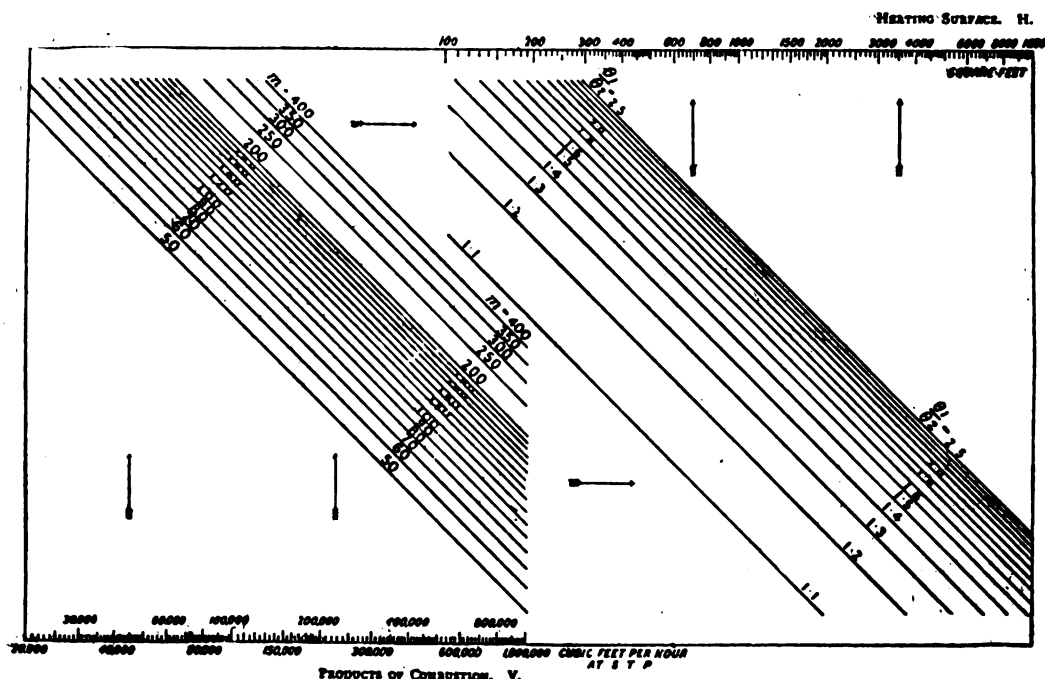


Fig. 3—Chart showing relation of products of combustion to heating surface in water-tube boilers of the Babcock type.

$$H = 2.3026 \frac{V}{m} \log_{10} \frac{\Phi_1}{\Phi_2}$$
 Where H = Heating surface in square feet. V = Volume of products of combustion in cub. ft. per hour. Φ_1 = Heat contents per cub. ft. of products entering boiler. Φ_2 = Heat contents per cub. ft. of products leaving boiler. m = Modulus of heat transmission through heating surface.

Table XIV.					
1. Test.	2. Heat gradient.	3. Vol. per min. H.S.	4. Product of 2 and 3.	5. Ht. trans- mission from test. Lb. Cal.	6. Ht. trans- mission from formula. Lb. Cal.
Exp.	214.3° C.	9.34	2002	961	1184
I.	257.4° C.	9.39	2416	1390	1258
II.	174.7° C.	10.02	1753	1076	1135
III.	280.8° C.	9.88	2775	1339	1314
IV.	198.7° C.	17.04	3386	1382	1401

Let—

G = Heat gradient as defined above.

S = Volume of products per minute divided by area of heating surface as defined above.

P = G × S.

T = Heat transmitted through heating surface in lb. calories per sq. ft. per hour.

It will then be found that if the common

values from the experimental results. It will be noted that the experimental boiler and No. 1 do not agree very closely, but that the others are in fairly close agreement. More experimental data are, however, required over a wider range of values, and it is hoped that any of the members who may have such data in their possession will be good enough to communicate them.

It will be noted that in fixing the heating surface we determine the ratio of heat contents of the products entering and leaving the boiler chamber, whilst in determining the heat transmitted per square foot of the heating surface what we require to know is the temperature entering and leaving the boiler chamber.

The temperature entering will, in the case of an existing furnace, be obtainable by actual measurement with a pyrometer, and in the case of a new furnace can be approximated from the known results obtained with similar furnaces.

To obtain the temperature of the products leaving the chamber, having fixed upon the ratio of $\frac{\Phi_1}{\Phi_2}$ it will be useful to have an equation connecting temperature with heat contents in a form convenient for use.

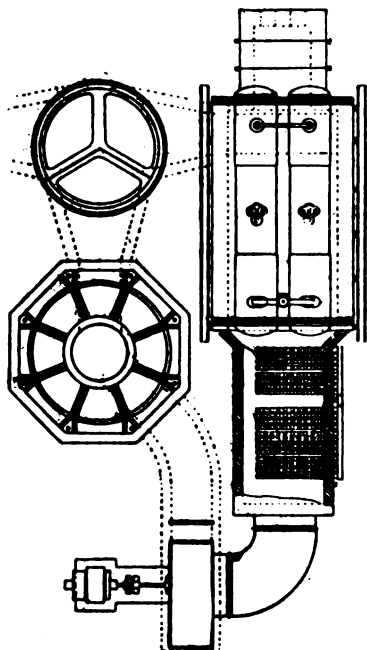


Fig. 4—Layout of Plant.

If the analysis of waste products given above be taken as a good average sample, the equation connecting temperature with heat contents is—

$$0.1951t + 0.000,003,6t^2 = \Phi = \text{heat contents per cu. foot.}$$

This quadratic equation is not particularly convenient for use, but if values are calculated, and their logarithms plotted with the logarithms of the temperature as coördinates, an equation is obtained which is easily solved with the aid of a table of logarithms. It is—

$$\log t^\circ \text{ Cent} = 0.939 (1.846 + \log \Phi) \quad \dots (10),$$

Table XV. gives values of heat contents corresponding to the most useful temperatures likely to occur in waste-heat boiler practice, and also the results obtained from equation 10.

Table XV.

Temperature in deg. Cent.	Heat contents per cubic foot Φ	Temperature from equation 10.
100	1.987	103.1°
200	4.046	202.2°
300	6.176	299.1°
400	8.379	398.4°
500	10.654	499.1°
600	12.996	599.4°
700	15.424	706.3°
800	17.912	813.0°

Another point which is of interest is the question of the resistance to flow of the hot products through

between the boiler tubes, and what suction, measured in water gauge, must be provided to overcome the resistance and still leave enough pull at the entrance to the boiler to maintain the draft necessary for the efficient operation of the melting furnace. The experience which has been gained in the past has practically been with boilers fired with either solid, liquid, or gaseous fuel in which there was actual combustion under the boiler. Under these circumstances the volume of the products of combustion is not so large as where the whole products from a large smelting furnace have to be dealt with. Making the same assumption which was made with regard to the rate of heat transmission, viz., that the rate of flow of the products is a function of the volume per minute divided by the heating surface, and calling this $f(v)$, it would appear that a simple linear equation of the form:—

$$0.16 f(v) = \text{suction in inches W.G.} \quad \dots (11)$$

will give results closely agreeing with the limited number of observations available, as Table XVI. will show:—

Table XVI.

$f(v)$	Suction entering boiler. W. G.	Suction leaving boiler. W. G.	Difference. W. G.	From formula W. G.
9.39	0.91 in.	2.43 in.	1.52 in.	1.50 in.
9.88	1.60 in.	3.05 in.	1.45 in.	1.58 in.
10.02	1.00 in.	2.50 in.	1.50 in.	1.60 in.
17.04	1.00 in.	3.75 in.	2.75 in.	2.72 in.

More experimental data are, however, required before the curve can be accurately determined. As none either of the boilers or economizers which were tested were prepared in any way for the test, but were taken in their actual working conditions, some of the discrepancies between the actual and the calculated results are no doubt due to the state of the tube surface as to freedom from deposit on the outside and scale inside.

None of the boilers above referred to were provided with superheaters, but there is no doubt that such could be quite well applied with the advantage of obtaining steam containing a greater store of energy.

With regard to the actual setting of the boiler, economizer, and fan, it is important to keep the passages short and direct, avoiding all quick bends, also to do everything possible to prevent air leakage. There must also be provided plenty of explosion doors, which must be air-tight when closed. So important is the prevention of air leakage that the author is of opinion that where waste-heat boilers are to be used the air valves of the furnace should be water-sealed, as the butterfly valves usually used for air are far from being tight.

A good layout of the plant is shown in Fig. 4, from which it will be seen that a three-way water-sealed valve of the drum type is arranged to send the prod-

ucts either to the boiler or direct to the chimney, and that the fan discharges back into the chimney, as even at their low temperature, after passing over boiler and economizer, some pull could be secured from the chimney to help the fan.

Collecting the more important results of the tests detailed in the first part of this Paper, Table XVII. is obtained.

The average of the weights of steam per ton of ingots is 987.5 lbs. As only one of the boilers in the above tests was receiving all the waste products of combustion, and it was too small to deal properly with the amount, while the others were only using about two-thirds of the products from their respective furnaces, there seems reason to believe that at least 1,200 lbs. of steam per ton of ingots would have been obtained under more favorable conditions.

Table XVII.

Item.	Exp.	I.	II.	III.	IV.
Heat usefully employed in boiler, lb. cal.	1,555,000	2,540,000	2,360,000	2,934,000	3,031,000
Weight of steam of dryness factor 0.95 generated per hour, lbs.	2,440	3,792	3,728	4,616	4,736
Weight of steam per ton of ingots, lbs.	1,084	949.3	855.3	1,252	796.9

Experience has shown that in a steelworks making plates and bars, and in which the power plant is not particularly up to date, most of the mill engines being of the simple high-pressure type, the shears being similarly driven, and even some of the live roller racks being driven by small and wasteful engines, whilst the pipe ranges are of considerable length, the steam consumption works out at 3,200 lbs. per ton of ingots. Even in such a case, therefore, the saving in boiler fuel which could be effected by the use of waste-heat boilers on the smelting furnaces would be 43.75 per cent. Another source of steam, which has not been dealt with in this paper, is the waste heat from the reheating furnaces. The volume of products would be less per furnace, but from some tests made it would appear that the temperature is higher. A very conservative estimate will therefore be, that under the conditions named above, a saving of 50 per cent in boiler fuel can be made by utilizing heat at present, in nearly every case, going to waste.

More experimental data are, however, necessary, and it is to be hoped that all of the members who may have such in their possession will, in the interests of engineering science, communicate them, so that the deductions which have been drawn from those herein recorded may be either confirmed or, where necessary, modified.

Record of an old Ferro-Silicon Furnace

**Historical Account of Blast Furnace Plant Originally Built in 1792,
Which Was Operated and Improved Upon First by the Southern
Iron Company and Is Now a Part of the Warner Iron Company.**

By I. PETERMAN.

The story of this furnace and its successor may be interesting to readers of the trade papers. According to accounts and history gleaned from the few old timers remaining in this district, the building of the original furnace occurred in 1792, this was further confirmed by the location of several stones, one of which was marked "J. R. 1792." I am unable at this time to state to whom the "J. R." refers. This early furnace was of the hillside type, the original foundations are still in existence but covered with slag and rock; the ore was mined on the hill adjoining the furnace and an old-timer tells me that they burnt the ore which I assume to be that it was roasted in some sort of a kiln before charging. There were two mines of brown ore in close proximity to the furnace and it seems that they mined the ore from the very hill to which the furnace adjoined, the pits are now almost filled up with rock and dirt from the washing of soil from the mountains, the burden was charged according to old methods found in conjunction with hillside furnaces.

Later, in 1832, this property was acquired by the Van Leers, a stone marked AWW-1832 was found on the property. This firm operated the furnace successfully at that time under the able management of a Mr. Stone. This gentleman is now one of our most successful farmers and has vast properties in this district which he and his sons farm today.

Sometime previous to, or during the Civil War, this furnace made cannon balls for the army of the Confederacy, several of the balls are in the possession of citizens of this district and one is at the company hotel. After the Civil War the furnace shut down and I am unable to learn what disposition was made of the machinery and outfit in general.

In 1892 the Southern Iron Company built a small stack about one quarter mile from the site of the original furnace and after a series of ups and downs common to the old-time stacks due to guesswork and "perhaps" methods of operation, the furnace was acquired by the Warners. This took place about 1883 and, if I

am correctly informed, a new furnace was built which, in those days was considered a marvel. I have no record of any changes being made in the furnace lines since that time. The stones spoken of are in the possession of the Warner Iron Company at their plant in Cumberland Furnace, Tenn.

This furnace is still running and will be running many years from now, they are producing a good grade of blast furnace ferro-silicon, some analyses of which follow :

Month	Year	Silicon	Sulphur	Phos.	Mn.
December	1917	7.79	.027		
December	1917	7.31	.021		
December	1917	8.40	.017	1.99	.25
December	1917	8.26	.019		
January	1918	10.34	.017	2.41	.27
September	1918	10.25	.046	.99	.43

The foregoing will serve to illustrate the kind of iron that has been made in the past two years. I have some laboratory records at hand showing iron of 12 per cent silicon, .019 sulphur, 1 per cent and under phosphorus and under .50 per cent Mn. In 1918 the burden was composed of brown ore, mill cinder, puddle cinder, mill scale and the usual rock and coke. Some analyses of brown ore used follows:

Although I have given only three analyses on Ore

B we use this ore in greater quantities than Ore A, in fact two-thirds of the burden is made up from Ore B. Our furnace is small, producing 50 to 75 tons as a usual days run. There are times when these figures are considerably increased.

Ore	Iron	Insol	Phos.	Mn.	Al ₂ O ₃
A	46.10	22.98			
	46.00	19.50			
	48.10	18.60	.38	.21	
	52.80	13.26	.18	.21	
	51.60	15.32	.22	.17	
B	46.00	21.60	1.21	.24	1.72
	49.98	14.20			
	20.00	20.00	1.06		

I would greatly appreciate any comments from outside furnace men in case I have made any errors, it may be my good fortune to get a more detailed account of these old-time furnaces at a later date and I will place them before the readers for comment.

In conclusion let me say that the officers of the present company are Mr. Joseph I. Warner, president; Mr. J. H. Bandy, secretary and treasurer, and Mr. E. W. Patterson, superintendent. The future of the furnace is assured as the company has two first class brown ore mines, results of analyses are given above. Further, these mines are just of recent opening. Both are strip mines.

Combustion Characteristics of Coals

Factors Entering Into the Success of Equipment Selected for Burning Different Kinds of Coal—Performance of Various Types of Stokers—Data on Grades of Coal.

Many factors enter into the success or failure of equipment selected for burning different kinds of coal. Not long ago careful consideration was given to the available fuels in different markets, and a particular stoking equipment was selected that seemed to be best suited for a particular kind of coal. In these critical times however, this viewpoint has necessarily been changed, and it is not now a question of choosing a particular kind of coal and then selecting the apparatus to burn that fuel but rather the selection of stoking equipment that will burn a wide range of coals. That is, it is not possible now to choose the coal that will be used for any particular industry, but the equipment must be selected and arranged to burn the coal that can be obtained, irrespective of the quality.

In selecting stoker equipment, four factors should be carefully considered. Surprisingly, the most important of these is not the kind of coal to be burned, but rather the load condition of the plant. These four factors, in the order of their importance, are:

- 1. Load conditions.
- 2. Available coal.
- 3. Draft conditions.
- 4. Application conditions.

The nature of the load, and the amount of coal to be burned by any particular apparatus, are most important, for the reason that if certain load conditions dominate, irrespective of everything else, stoking apparatus must be selected for the condition. This is also necessary for the reason that different types of stokers can burn the same kinds of coal, but each type of stoker is limited as to the continuous overload capacity that can be successfully maintained and as to its maximum reserve possibilities. For example, an overfeed stoker will burn West Virginia coal very satisfactorily up to possibly 200 per cent of boiler rating. On the other hand, the multiple-retort underfeed type of stoker will burn this coal equally successfully at 200 per cent of rating, but it is not limited to this capacity, as 300 and 400 per cent of rating can be obtained. In a case of this kind, the load conditions would decide the stoking equipment best suited for the work.

Coals in United States.

The combustion characteristics of coals mined throughout the United States vary considerably. Starting in the eastern portion are the anthracites, and

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such coals as Pocahontas, Clearfield and New River from West Virginia and Maryland, gradually getting into the Pittsburgh and Ohio coals. In the Middle West are Illinois, Missouri and Kansas coals which, with their free-burning characteristics, are entirely different from the eastern coals. Going farther west are the Denver lignites with their high percentage of moisture, which again are different from the lignites of Texas and North Dakota.

Various poor grades of these coals must be contended with by central stations and industrial plants, and the object of this paper is to outline briefly, the action of these coals on different types of stoker equipment. Only the type of stoker equipment best suited for load and coal conditions is discussed; the draft and setting conditions, on the other hand, might be the deciding factor in a particular installation.

Anthracite Coals.

The larger sizes of anthracite coal are taken for domestic use, and only the smaller sizes are available for firing steam boilers. On account of the small size this coal is very difficult to burn, and in general nothing has as yet been devised to handle this fuel successfully. On account of the high percentage of fixed carbon in the coal, it is difficult to ignite, and expert firing must be used to obtain any results at all. In burning this coal, a slight pressure is used under the fire.

A few years ago, evaporative tests were conducted on the overfeed type of stoker with the smaller sizes of Nos. 1, 2 and 3 buckwheat coal and fairly good results were obtained as given in Table I.

Another test on the overfeed type of stoker gave an equivalent evaporation of 8.4 lbs. of water from and at 212 degrees F. per pound of dry coal when using a mixture of run of mine bituminous coal and anthracite buckwheat. No. 2, in the proportions of one-quarter bituminous to three-quarters anthracite. This result was obtained when the boiler was operating at approximately normal rating.

Table I—Performance of Overfeed Stoker.

Applied to 250 and 500-hp. boilers when burning buckwheat anthracite coal.

Performance characteristics.	250 hp.	500 hp.
Percentage of boiler rating during test.....	77.6	87.4
Duration of test, hours.....	9.5	10.
Temperature of flue gases degrees F.....	713	581
Pounds of dry coal per sq. ft. of grate surface per hour	14.5	13.7
Equivalent evaporation from and at 212° F per lb. dry coal	7.21	8.63
Equivalent evaporation from and at 212° F per lb. combustible	8.54	10.67
Coal used—P. & R. anthracite rice:		
05.7 per cent passing through a 3/8-inch round mesh		
41.6 per cent passing through a 3/16-inch round mesh.		
4.7 per cent passing through a 1/16-inch round mesh.		

Although the handling of this coal on an overfeed type stoker, as stated above, gives fairly good results, it is not so successful that, it could be used generally.

That is, each successful installation seems to be surrounded by good local conditions and a good understanding of the requirements of burning this coal. There are many plants in service giving good results.

This coal has been burned on many types of chain grate stokers, but has not, in any way, been successful except on that type using grate bars particularly designed for fine anthracite coal and permitting the use of air pressure under the fuel bed. There have been many recent installations of this type of chain grate for handling small sizes of anthracite coal, and although definite information is not available at this time, this method promises to excel others for this particular coal.

Attempts made to burn the fine anthracite coals on the underfeed type of stoker have generally been unsatisfactory. On account of the high fixed carbon content of anthracite coal, there is no question but that it can be handled best on a flat grate or an overfeed type of grate or stoker. While attempts to burn this coal on an underfeed type of stoker have proven unsuccessful, a mixture of eastern bituminous and anthracite screenings has been burned satisfactorily.

Table II—Effect of Various Percentages of Anthracite Coal.

Anthracite Coal	Cost of Mix-	Cost of Coal per 1,000 lbs. of	
Per cent of Mix-	ture per	Water from and at 212° F.	
ture	ton	Dollars	%
Mixture	Dollars		
0	3.00	0.132	100
25	2.625	0.126	96
33.3	2.50	0.123	93
40	2.40	0.120	91
50	2.25	0.120	91

The objection, however, to this is that an elaborate mixing scheme must be used to obtain a proper and thorough mixture of the two fuels.

Recent tests conducted on the inclined underfeed stoker show that about 600 lbs. of a mixture of 50 per cent anthracite and 50 per cent bituminous coal can be burned per retort per hour. Of course, the object in burning a mixture of bituminous and anthracite coal is to reduce to a minimum the cost of making steam. The relative cost of the anthracite and bituminous coal is, therefore, the main factor. As the percentage of anthracite coal is increased, the total amount of coal necessarily burned also increases, due to the lower heating value per pound of the mixture, and also the lower efficiency. Test results show that from a zero percent mixture of anthracite with bituminous coal to a mixture of 50 per cent anthracite and 50 per cent bituminous, the efficiency dropped 7 per cent. The amount of refuse handled also increases when burning this mixture, and the fixed charges increase due to a reduction in capacity. There is also, as stated above, an additional cost of mixing the two coals. As all of these factors vary for different plants and localities, the percentage of anthracite coal that will permit minimum unit costs differ so that each individual case must be considered when the individual conditions are known.

To illustrate, in Table II is shown the cost of evaporating 1,000 lbs. of water from and at 212° F. on the basis that bituminous coal costs \$3.00 per ton and anthracite coal, \$1.50 per ton.

Eastern Bituminous Coals.

The coals used in most of the large representative central stations and industrial plants in the East are mainly the semi-bituminous and bituminous coals



Fig. 1—Installation of stokers of Norfolk & Western Railway Company's Plant, Bluestone, W. Va.

coming from West Virginia, Pennsylvania, Maryland, etc. This coal can be burned very successfully on the overfeed and the inclined underfeed type of stoker; also on some types of single retort underfeed stokers. On account of the characteristic caking of this coal when burned, the chain grate stoker is not suitable. The selection of either an overfeed or an underfeed type of stoker is then reduced to a question of load conditions.

For the large central station plants where extreme flexibility is required in the equipment in order to take care of peak loads and sudden demands for steam, there is no question but that the multiple retort inclined underfeed stoker should be used. In industrial plants, where not more than 200 per cent maximum reserve capacity is required in a stoker equipment, the overfeed type of stoker, will, in the final analysis, give the best results. For example, with the inclined underfeed type of stoker, a range of operation can be obtained from 50 per cent of boiler rating to 400 per cent of boiler rating with very little difference in efficiency, as shown in Table III. For the overfeed type of stoker, the range of operation is within the limits of 75 to 200 per cent of boiler rating.

A few years ago, the most successful type of stoker for handling Pittsburgh coals was the overfeed type, and even today it is questionable whether, within the limits of the operation of this type of stoker, more satisfactory equipment can be obtained. The inclined underfeed type of stoker, having come into use in the

last few years, has shown its ability to handle Pittsburgh coal very easily and, in addition, is giving more satisfactory results than are obtained with the overfeed type of stoker when higher ratings must be obtained from the boilers. Therefore, in the selection of a suitable stoker equipment for burning this coal, the load condition would decide the question as to whether or not the inclined underfeed type would be used or the overfeed type of stoker.

Table III—Performance of Underfeed Stoker.

Applied to a 400-hp. boiler when burning eastern bituminous coals.

Per cent of boiler rating during test	50.7	103	145	202	1361
Duration of test, hours.....	25	24	13.25	24	2
Temperature of flue gases, degrees F.	429	465	505	605	743
Pounds of dry coal per sq. ft. of grate surface per hour..	—	16.4	23.7	33.5	75.2
Carbon dioxide, per cent.....	12.7	14.3	12.7	13.6	15.4
Per cent of efficiency of boiler, furnace and grate, based on dry coal	79.7	78.02	76.6	75.5	59.8
Approximate Coal Analysis.					
Per cent moisture	.4				
Per cent volatile matter.....	24.1				
Per cent fixed carbon.....	68.6				
Per cent ash	7.28				
B.t.u. dry	14963				

There are many plants in the Pittsburgh district where chain grate stokers are used. While it cannot be said that this stoker is wholly unsatisfactory for these fuels, on account of their coking qualities and the characteristic caking effect, the principle of the chain grate stoker is fundamentally wrong for such coals.

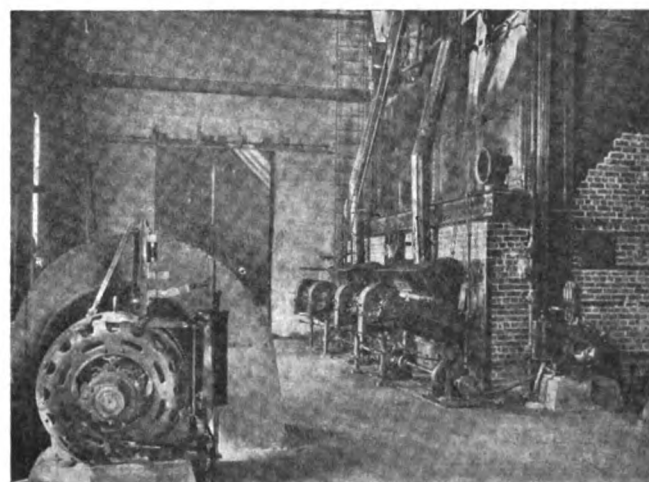


Fig. 2—Underfeed stoker installation.

Table IV—Performance of Overfeed Stoker.

Applied to 335-hp. boiler when burning Pittsburgh coals.					
Per cent of boiler rating during test.....	105	210			
Duration of test, hours	10	8			
Temperature of flue gases, degrees F.....	503	718			
Pounds of dry coal per sq. ft. of grate surface per hour	17	38			
Calorific value of dry coal per lb.....	13428	13202			
Per cent efficiency of boiler, furnace and grate based on dry coal	75.5	68.8			

The manner in which they act on a chain grate stoker was quite apparent in a test recently conducted on a chain grate stoker having a front choking plate. As the coal ignited, it was pushed off this coking plate by means of plungers and it passed onto the chain part of the stoker in large lumps, resembling blocks. On this particular stoker, forced draft was

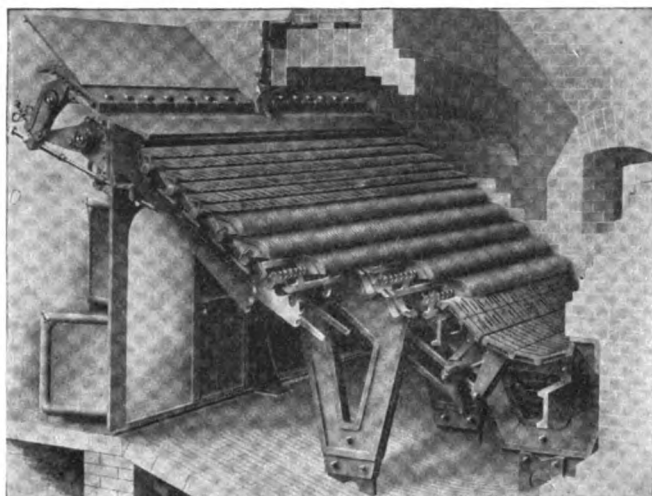


Fig. 3—Overfeed type of stoker.

used. By viewing the furnace fire, it could be seen that the air was going up between these blocks of coals and not through them. In other words it seemed that if one could get into the furnace and paddle down the fuel bed, covering up these holes, proper results could be obtained. In general, this is the action of this coal on any type of chain grate stoker.

Coke Breeze.

In the Pittsburgh district, there is considerable coke breeze that is now without a market, due to the fact that there is nothing that can satisfactorily burn it. Many attempts have been made to burn this on the overfeed type of stoker, and all of these have resulted in miserable failures. The best way to burn coke breeze at the present time is on a flat grate with a medium pressure under the grate. A special design chain grate type of stoker is being installed in many plants and promises to give a really successful way to handle this fuel mechanically. Forced draft is used with this stoker. Attempts are now being made to burn this breeze on the underfeed type of stoker, but no commercial success has yet been attained.

Middle West Coals.

In the Middle West, where Illinois grades of coal dominate, in general, the chain grate type of stoker is most suitable for limited boiler outputs—up to about 200 per cent of boiler rating. It is surprising, however, to find that in Indiana, where the coal veins are adjacent to those of Illinois, the overfeed type of stoker is more generally used. This is because some

of the coals in Indiana have more of a coking or caking nature than a free burning characteristic.

The inclined underfeed type of stoker is now being installed for handling Middle West coal, and the one thing that will make it permanent is the flexibility of the equipment and the possibilities of higher boiler ratings.

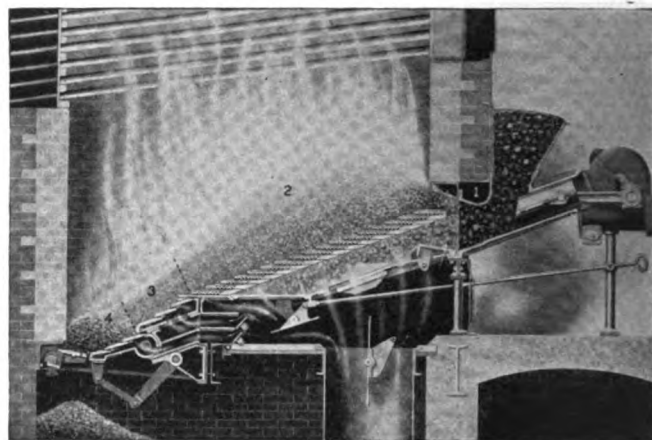


Fig. 4—Section of furnace chamber, underfeed stoker.

Table V.—Performance of Chain Grate Stoker.

Applied to a 514-hp. boiler when burning low-grade Illinois coals.

Per cent of boiler rating during test	117	150	169	189
Duration of test, hours.....	8	6.5	8	8
Pounds of coal as fired per sq. ft. of grate surface per hour	32.9	43.2	44.9	47.3
Carbon dioxide, per cent.....	6.3	8.1	9.5	10.3
Per cent efficiency of boiler, furnace and grate based on dry coal	88.6	65.3	65.1	60.8
B. T. U. per lb. of coal as fired	10550	9205	10010	11350

Lignite Coals.

Years ago, the overfeed type of stoker was installed in the west to burn Denver lignites, and was not gen-

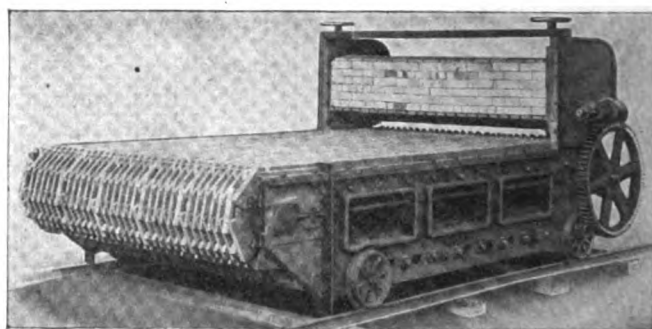


Fig. 5—Chain grate stoker.

erally satisfactory. There are many chain grates burning this coal and, in a general way, it might be said that they are fairly satisfactory. There is nothing, however, that has successfully handled this fuel in a commercial way and considerable development work is now being done in an endeavor to apply or change

the inclined underfeed type of stoker to handle this coal. This type of stoker has one characteristic which is particularly adapted for lignite, and that is that a very heavy fuel can be carried, and the air supply adjusted, which eliminates the difficulty of blowing holes through the fire and distributing dust and ash onto the heating surfaces of the boiler.

Table VI—Performance of Underfeed Stoker.

Applied to a 558-hp. boiler when burning Illinois Cartersville Coal.

Per cent of boiler rating during test	163	182	212	328
Duration of test, hours.....	12	12	12	2
Temperature of flue gases, degrees F.	512	489	562	633
Pounds of dry coal per sq. ft. of grate surface pr. hr..	227.7	34.9	37.2	62.3
Carbon dioxide per cent...	13.6	13.4	13	15.1
Per cent efficiency of boiler, furnace and grate, based on dry coal	77.7	76.1	76.4	
Calorific value of coal as fired, B.t.u per lb.....	11877	10226	11232	11378

Average approximate coal analysis.

Per cent moisture	10.3
Per cent volatile matter.....	28.9
Per cent fixed carbon.....	41.8
Per cent ash	18.9
B.t.u. as fired	10226
B.t.u. dry	11401

North Dakota lignite coals have been tested, in a general way, on the inclined underfeed type of stoker mainly to ascertain the method of firing, and the characteristic action of this coal on this type of stoker. It

was found that the coal was extremely easy to handle and any clinkers that formed could be easily removed at the rear of the stoker. During this test, the results of which are given in Table VII., it was thought that considerable higher ratings could be obtained if the equipment had been originally designed for feeding this grade of fuel. In all of the tests, very little clinker trouble was encountered, and it was not necessary to dump the fire during the seven hour test.

There are lignites in Texas that still require some satisfactory means of burning. About every type of stoker has been tried out on this coal but no one seems to have especial advantages that would demand its general use. Attempts are now being made to handle this on the underfeed type of stoker but it yet remains to be determined whether or not this type will be satisfactory.

Table VII—Performance of Underfeed Stoker.

Applied to a 600-hp. boiler when burning North Dakota lignite coal.

Pounds of dry coal per sq. ft. of grate surface		
Per cent of boiler rating during test.....	123	139
Duration of test, hours.....	6	7
Temperature of flue gases, degrees F.....	467	467
per hour	32.4	31.4
Carbon dioxide, per cent	13.2	12.6
Per cent efficiency of boiler, furnace and grate, based on dry coal.....	56.2	64.6
Approximate analysis of coal.		
Per cent fixed carbon.....	30.0	30.3
Per cent volatile matter.....	20.7	28.3
Per cent moisture	34.4	33.5
Per cent ash.....	5.9	7.9
B.t.u. as fired	7029	7120

Niter Cake Substitute for Pickling Steel

Investigation Conducted by United States Bureau of Mines
Chiefly for the Purpose of Conserving Sulphuric Acid Shows
the Possibilities of Using Nitre Cake for Pickling Steel.

By E. E. CORBETT.

Other substances than colloids are materially effective as inhibitors or polarizers; sodium sulphate acts in such a capacity, chiefly perhaps in reducing the electrolytic dissociation of the acid and in neutralizing the influence of the ferrous sulphate—possibly by forming with the latter an undissociated, or little-dissociated, double-salt in solution. Its usefulness in pickling is more or less accidental—secondary to the important proposition of utilizing the comparatively large quantity of sulphuric acid which occurs in niter cake, a by-product in the manufacture of nitric acid, and which is available for metal cleaning as well as for many other chemical purposes.

Niter cake is, popularly, a mixture of neutral sodium sulphate with a varying proportion of sulphuric acid; more properly, it is an impure acid sulphate or bisulphate of soda carrying a variable excess of sodium sulphate or, infrequently, of sulphuric

acid, from kettles improperly charged or prematurely drawn. Sodium bisulphate contains, chemically, 40.6 per cent sulphuric acid combined with 59.4 per cent sodium sulphate in the double salt of the formula NaHSO_4 . Niter cake may occasionally have the same approximate composition, but its acidity usually ranges between 28 per cent and 44 per cent sulphuric

Silica	0.10%
Oxides of iron and aluminum.....	.45
Freed acidity, H_2SO_4	34.55
Sodium nitrate	.05
Sodium sulphate	64.75
Sulphates of calcium and magnesium....	Trace

acid, depending on the working conditions surrounding its production. In addition to the substances already mentioned, the cake contains small percentages of iron, aluminum and silica as regular impurities, with traces of arsenic, sodium, nitrate or nitric

acid as accidental impurities. The foregoing analysis is fairly typical of its composition.

Occasional samples, from runs in which impure chamber acid has been used, show a trace of arsenic but the occurrence of this element in niter cake is generally rare.

Acid salt cake differs from niter cake chiefly in the method of its preparation. Acid salt cake is the corresponding by-product of the hydrochloric acid still; it is formed by the interaction of sodium chloride with sulphuric acid, and contains in addition to 30 per cent free sulphuric acid and 67-69 per cent sodium sulphate traces of hydrochloric acid, chlorine and its oxides, sodium chloride, and other minor impurities incidental to the occurrence of common rock salt. The free acid is totally available for metal cleaning—the reaction mechanism is substantially identical with that of the niter cake solution. The presence of free hydrochloric acid, or of sodium chloride, in conjunction with free sulphuric acid, is of distinct advantage in the cleaning of alloy steels and of heavily rusted carbon steels—in fact a mixture of sulphuric and hydrochloric acids is the most satisfactory medium for this grade of work. The best English practice specifies the use of such a mixed acid in cold solution where time permits of the slower rate of reaction.

The manufacture of hydrochloric acid for metallurgical purposes, however, is carried out not infrequently today on hearths on which sodium chloride mixed with ground niter cake is roasted under conditions which yield simply hydrochloric acid and neutral sodium sulphate. This neutral salt, ordinary anhydrous Glauber's salt, finds its chief utilization in glass-making; and as, unlike niter cake and acid sodium sulphate, it possesses no acid properties, it is not a pickling, or metal-cleaning agent.

Niter cake is, then an indefinite chemical compound which, like sodium bisulphate, or acid sulphate, breaks up in solution into sodium sulphate and free sulphuric acid, entirely available as such for metal cleaning. Thus the pickling capacity of one pound of the niter cake whose analysis is cited above is equivalent to 0.37 lb. 66° Be. (93.2 per cent) sulphuric acid, or to 0.44 lb. 60° Be. (78.04 per cent) sulphuric acid.

These figures are based on actual plant tests, and agree substantially with those calculated from theoretical considerations. The conclusion to be drawn from them is plain: the acid present in the thousands of tons of niter cake produced in the manufacture of nitric acid for explosives may be utilized to the extent of releasing an equivalent amount of technical acid from industries which may find it economically practicable to adapt their processes to the use of a substitute. The niter cake which is left to weather in the open, soaking into the land and polluting the streams, is a source of manufacturing nuisance, as

well as an economic waste, the correction of which would partially relieve the strain on sulphur and acid production. A number of industries are qualified to assist in ameliorating this condition; steel manufacture alone might absorb 30,000 to 50,000 tons of niter cake, releasing 10,000 to 15,000 tons of sulphuric acid (100 per cent) per month without seriously interfering with its present output.

Cleaning with niter cake solution does not differ essentially from pickling with acid, but it introduces certain necessary manipulative changes due to the presence of sodium sulphate in large proportion as a diluent. Sodium sulphate in hot concentrated solution tends to reduce the activity of the acid; as a result, pickling with niter cake alone requires from $1\frac{1}{2}$ to $2\frac{1}{4}$ times the period demanded by acid under similar conditions. This retarding circumstance applies to the use of niter cake of approximately 33.3 per cent acidity, in which the ratio of sodium sulphate to free acid is 2.1. As, however, the niter cake solution may be further activated by the addition of technical acid, it is found in actual experience that as the ratio, sulphate to acid = 2, is diminished, the pickling time for niter cake solution approaches that for acid alone; until, at unity, the niter cake solution acts as rapidly as acid. The reaction velocity of the solution of niter cake of acidity 41 per cent is at least twice as great as the solution of a cake of 32 per cent acidity at the same temperature and concentration. Hence, a mixture of three parts of niter cake with one part of 60° acid, or four parts of niter cake with one part of 60° acid should serve to maintain normal production and at the same time effect a saving of acid. In some processes it has been found practicable after a few experimental runs to substitute acid entirely with niter cake; the time element involved in experiment and operation, however, forbids entire substitution in most work.

The addition of sodium sulphate with acid, as an unavoidable component of niter cake, tends to decrease the life of the bath because of the comparatively rapid increase of solids in a solution; a niter cake solution dies down twice as fast as acid of the same strength. Consequently the tubs must be cleaned more frequently, especially when 8.10 per cent acidity is the normal working concentration. In most works operating with niter cake solution the bath is made up with niter cake and acid sufficient to give the desired strength for pickling (2.10 per cent free H_2SO_4 , reckoning the acidity as H_2SO_4 vs. water, rather than H_2SO_4 vs. weight of solution); successive additions of niter cake and acid are made during the day as deterioration of strength demands until the density of the hot solution approaches specific gravity 1.26 to 1.28. "Killing down" is then begun; the temperature of the solution raised to 200 to 205° F.

and maintained until analysis shows an acidity of 0.002 to 0.004 gm. H_2SO_4 per c.c.

Control analyses are made by titrating 10 c.c. of the pickle liquor against normal sodium carbonate, Methyl Orange indicator; or with normal sodium hydroxide, the formation of a small permanent iron hydroxide turbidity being taken as the end point. Each cubic centimeter of standard alkali represents approximately 1 per cent of free acid by volume.

It is not practicable to use a niter cake solution after the concentration of inert salts has by repeated additions been raised to the equivalent of 44-50 parts of sodium bisulphate in 100 parts of solution. If such a solution be cooled to atmospheric temperature crystals of ferrous sulphate may be recovered and the mother liquor again used for the acid which it carries; but the large proportion of sodium sulphate increases until it finally reduces the mobility of the liquor to a low efficiency.

Occasionally it is found practicable, through normal interruptions of operation, to let settle the particles of scale and other extraneous matter suspended in the bath, to draw off five or six inches of "sludge" from the bottom of the tank and replace with an equal volume of water and niter cake.

By the installation of a supplementary system for continuous operation in conjunction with the pickling the settling may be even more comprehensively effected. Such a system involves the use of two extra tanks separate from the actual pickling vats. The initial cost of installation is moderate, the cost of maintenance small.

The first of the supplementary tanks serves partly as a pass tank, into which the partially spent pickle solution may be dropped by gravity prior to being raised by steam-injector, air-lift, or compressed air to the main settling tank. The latter, in turn, is placed on a higher level than the main pickle tank, to permit again of gravity flow from the upper levels, gauge-controlled, back to the working tank.

The first, or pass-tank, may, by the introduction of the necessary steam coils and proper ventilation, be used as a dissolving or fortifying tank. Here the acid or niter cake is run in and dissolved to the necessary amount, and the solution then raised to the main settling tank, in which dirt and suspended rust and scale are deposited and at intervals drawn off at the bottom with such sulphate crystals as may separate as the liquor cools. In this way scale and crystals may be recovered, the solution cleared and its gravity and consequent viscosity reduced while the acidity may be maintained at a practically constant value.

A system of this general type is by far the most economical for handling pickle liquors. Reasonable care in its operation tends to eliminate losses of small percentages of acid which are ordinarily run to the sewer; to minimize the spotting of material resulting

from the red oxide deposits carried out of dirty solutions and which are often with difficulty rinsed off in the wash tanks; and to give a mobile cleaning solution at all times of uniform acidity and free from suspended undissolved salts.

The process necessitates no interruptions; it provides a continuous cycle of operations in which the dissolving of pickling agent, cooling, crystallizing and settling are permitted a sufficiently long interval in which to keep up with pickling, provided a fair reserve of solution is kept in circulation in the liquor storage. Solutions may be rejected and renewed without interfering with the cycle.

The system is applicable to both hand and machine, as well as plunger, pickling—especially to those processes of pickling heavy stock in which it is not uncommon practice to run the solution to the sewer as soon as the material is cleaned without making a determination of spent acid and regardless of the waste which is entailed in such summary starting of the tank plugs.

With proper chemical supervision the crystallization in the settling tank may be so controlled as to yield, from the stronger solutions, a good technical grade of ferrous sulphate.

Sodium Sulphate as an Inhibitor.

Aside from its influence in retarding pickling, sodium sulphate serves, as stated above, as a beneficial inhibitor. It appears to act in conjunction with the free acid and ferrous sulphate in such a way as to restrict attack to those scaled regions of the bar or plate at which the occurrence of sound metal and scale together realize the conditions of an electrolytic cell; the effect is a thorough disintegration of the oxide mass rather than the undermining of scale which acid alone accomplishes.

In such a cell the solution of acid, ferrous sulphate, sodium sulphate, completes a local circuit between sound metal and the mixed scale oxides, FeO , Fe_2O_3 , Fe_3O_4 , setting up a condition similar to that which obtains in the systems designed for electric or electrolytic pickling. Iron goes into solution to form ferrous sulphate; the equivalent of hydrogen liberated polarizes on the sound metal, blanketing it and so making the area temporarily passive to the action of the acid.

The current locally set up splits ionic sodium from the sodium sulphate present in the solution; the sodium discharging in the pores of the sound metal immediately lays a more permanently protecting film on the ferrite surface. As the layer of scale is not continuous, but practically invariably broken by numberless fine but distinct cracks, it is not subject to the same protection by ionic metal discharge; it is therefore, laid open to the action of the nascent hydrogen which, by reducing the higher oxides to ferrous oxide and disintegrating the mass leaves the scale in a condition of greater solubility in the free acid. It is

probably due to this physical and chemical condition that a surface which has been deformed by mechanical stresses in rolling or drawing immediately before pickling is much more readily cleaned than a heavily rusted surface or one which has been open-annealed but not worked.

In consequence, theory and practice both bear out the assumption that the attack should be uniform over the entire plate and on occasion so localized that extra long immersion in the hot solution for the removal of the more obstinate patches of hard-burned, partially rolled-in scale should not result in a badly burned, pitted surface.

The results of long immersion show clearly the relative intensities of acid and niter cake solutions. A strip of metal left in niter cake solution during 8 or 10 hours will have at the end a smoother, less pitted surface than a similar strip left an hour in acid of the same strength and under the same conditions. A further economy may be observed at the spelter pots; stock may, without material loss, be left in niter cake solution until the hard patches are dissolved; consequently wasters and redips because of insufficient pickling are infrequent. These facts alone strongly recommend niter cake where its use is not forbidden by other conditions.

Material so pickled has a smooth finish, superior for coating, especially galvanizing. The covering of salt solution which it carries from the bath protects the surface from rapid rusting; but prior to coating, this film of salts must be removed by thorough rinsing, else it remains in the pores of the material and interferes with adhesion of the metal or alloy used for plating.

It is useless to attempt to coat material from which the film or smudge of pickle liquor has not been washed. The sulphates from the bath are not zinc or tin fluxes; they simply introduce an injurious coating on which the metals will not flow with adhesion. The same may be said particularly of a liquor filmed surface which is to be enameled or electro-galvanized; the material must be thoroughly rinsed before coating, else troublesome defects will cause rejections at every subsequent stage of finishing. This situation may follow from acid cleaning, however, as truly as it may from the use of niter cake solutions.

Materials Used in Conjunction With Niter Cake and Acid.

The pickling solution of niter cake and acid may be still further modified by the addition of other substances in small quantities to produce specific effects. Thus, a fraction of a per cent of an organic body, such as spent tanbark, quebracho fiber, waste sulphite liquor from the extraction of pulp-wood chips, or of one of the various non-fume or no-gas compounds on the market, serves to blanket such acid fumes as may be carried out by the steam, and at the same time

assists in removing oil or grease deposits from the metal. Again, calcium fluoride helps to slough off particles of furnace bottom which sulphuric acid only with difficulty effects. Finally, sodium chloride added to the cleaning solution accelerates attack on alloy scales, particularly those containing nickel and tungsten; while nitrate of soda is apparently without beneficial action; the presence of free nitric acid causes pitting of low carbon steels, notably in the case of metal for wire and tubes.

In connection with the pickling of material to be coated, especially sheet for tinning and galvanizing, arsenic and antimony, whether occurring in the acid or in niter cake, are exceedingly troublesome impurities. As soon as the acid begins to act on the iron or steel, the hydrogen liberated reduces the arsenic and antimony from their compounds, depositing the black elements on the surface of the sheet. It is practically impossible economically to remove these elements in after treatment; the result is a sheet or plate showing uncovered patches or pinholes to which the tin or zinc has not adhered. Furthermore, 105-110 lbs. of arsenic-bearing chamber acid are required to effect the cleaning of a total surface which ordinarily demands 100 lbs. of arsenic-free contact acid.

Shipping and Storage.

The handling of niter cake introduces problems of shipment, transportation and unloading, storage, which have not been adequately met. The cake is placed on the market as a roughly broken deliquescent solid which absorbs atmospheric moisture nearly as rapidly as does strong acid. Consequently it must be transported and stored in compartments designed to prevent exposure and weathering. Water readily leaches out the acid, reducing the effective acidity of the exposed cake and destroying iron or steel parts and fittings with which it comes into contact.

The cake is commonly shipped in ordinary unprotected wooden box cars which in this service are necessarily short lived. The strong fumes from some varieties of cake ultimately soften the wooden linings in damp atmospheres; the acid rapidly corrodes bolts, rods and nuts; the drip through the flooring attacks the springs and trucks. Further, steel material shipped in cars which have been used for niter cake transportation is not infrequently so seriously attacked and rusted as to become liable to rejection at its destination.

Special cars should be diverted to this service exclusively. The woodwork of the interior should be protected with an asphalt or mineral jelly paint, and all exposed iron parts covered with sheet lead. Niter cake storage bins should be similarly protected. Wooden floors are generally satisfactory, more especially where drains are provided to run off the drip which may result from exposure to unusually moist atmospheric conditions. Concrete and brick floorings

are unsuitable except where acid resisting brick and cement are used in conjunction. The cake must be treated in short, as regards its moisture drawing properties and corrosive attack on ordinary materials, with much the same care that is accorded to strong acid.

The atmosphere of gases which accumulates in the closed boxcar above the cake may contain nitrogen oxides as well as traces of chlorine and iodine. These gases are best removed by displacement with a jet of compressed air before putting men into the car for unloading.

Cost.

In calculating the economy of niter cake pickling of steel over acid cleaning, a fair average charge for extra labor at the present rate, in handling between the car and pickling tanks, may be taken as \$1.10 to \$1.25 per net ton of niter cake.

Further, the computation of the cost of niter cake with the necessary freight charges must take into account the fact that the effective acidity, or pickling intensity factor, of the cake is approximately 30 per cent of its weight. Actual experience in operation shows, however, that under proper control the acid of niter cake, modified by the presence of sodium sulphate, is from 10 to 15 per cent more effective in scale removal than an equivalent pure acid solution used under similar conditions.

Summary and Extension.

1. From 10 to 20 per cent economy may be effected in steel cleaning by (a) suitable temperature regulation designed to check fume loss as well as steam and fuel waste; (b) the use of polarizers or inhibitors adequate to minimize dissolving of sound metal and to blanket entrainment of acid in vapors rising from the surface of the bath; (c) methodical chemical and mechanical control maintained to prevent live steam losses at worn fittings and acid waste in splashing, leaky equipment, and in spent solutions rejected before the acidity has dropped to a specified limit of 0.3 to 0.5 per cent or less.

2. Except in the cases of a few special processes, niter cake may be substituted for 50 per cent of the acid now used for steel pickling. In those industries where time is not the controlling consideration the substitution may after trial be made even entire. The maintenance of production and the lining up of co-ordinate operations demands with present equipment, however, the use of acid to accelerate the action of the niter cake solution; otherwise total substitution requires a 30-50 per cent increase of tank equipment.

The exceptional instances in which the adoption of niter cake pickling tends to introduce disproportionate hardship include (a) highly polished hard steel wire and drill rod; (b) butt-welded tubing for enameled conduit, the interior of which must be energet-

ically pickled with a readily mobile, rapidly circulating acid solution for the removal of siliceous furnace bottom without undue reduction of the exterior wall; (c) the finer grades of tin-plate; and (d) those processes and plants in which the spent pickle liquor is concentrated for copperas recovery.

Sand-castings should be cleaned with a mixture of sulphuric and hydrofluoric acids. High nickel-chrome and tungsten-vanadium-chrome alloy rod and wire are best pickled in mixed hydrochloric-sulphuric acid, or with sulphuric acid in conjunction with common salt.

3. The chief objection to the use of niter cake in the cleaning of tin plate and sheet stock appears to rest on a physical or mechanical problem. The cake is ordinarily added to the machine tanks in lumps, which, dissolving irregularly, lead to momentary irregularities of acid concentration and consequent burning of the sheet; or, added as a powder or ground cake at the surface of the bath, it deposits on the sheet and causes local pitting or smudging which appears on the finished material as pinholes or blisters. The preparation of clear solutions would seem to be the proper corrective of these faults.

4. The shipping and handling of niter cake demands special cars and storage and an increase of transportation tonnage over that required for the equivalent acid. The increase of labor for handling is an essential item, though not a serious one except where extreme labor shortage exists. Control of operation at the pickle tanks requires certain alterations of process of handling which the majority of plants are prepared to make.

5. The exploitation of niter cake as a commercial material has been only too frequently accompanied by enthusiastic, but extravagant assertion of its effectiveness as cure for all the ills incident to pickling. Unquestionably it produces in most work a better metal surface than does acid alone; it reduces the fume nuisance; effects a saving of metal and acid; and aids in the utilization of a valuable technical product whose rejection at the point of production is a vast economic waste. But it can be regarded as a total substitute for sulphuric acid only under exceptional circumstances; its action is substantially slower than commercial acid solutions, and the labor required to handle it is necessarily greater. Its use as a beneficial substitute demands intelligent experiment until the conditions governing its behavior in each separate line of work are fully understood.

To determine the relative values of sulphuric acid and niter cake, and their mutual influence when used in conjunction, it is desirable to form as definite a conception of the action of the pickling agent as the scant available data of research combined with considerable practical working observation seem to warrant. Much of the material for the above report has been secured from large scale operations

Coke Factors Affecting Furnace Operation

Coke Testing Machine Employed as Experiment for Determining Coke Hardness—Program of Coke Hardness and Furnace Operation—Mechanical Condition of Coke Important Factor in Furnace.

By G. D. COCHRANE.

When I accepted the invitation to read this paper, I hoped to be able to devote a considerable amount of time to its preparation and to the collection of information and experiments of a practical and scientific nature bearing upon the subject, but it has only been with great difficulty that I have managed to find time to write the following lines.

It has been no easy matter to keep my remarks within the scope of the blast-furnace plant, as the onus of the manufacture of the coke is with the coke-oven manager, and it is to him the blast-furnace manager has to look for the regularity and quality of his supplies. It, therefore, is no uncommon occurrence to find that the chief concern of the coke-oven manager is to get as large a percentage of coke and by-products from his ovens as possible and, so long as those percentages are satisfactory, to pay little attention to the mechanical condition of the coke made, with the result that the blast-furnace suffers.

I propose laying down an axiom and supporting it by a few facts that have come to my notice during the past few years, and when I have finished you may criticize my argument but not convince me against it. It is this: "The practical success of the working of a blast-furnace is chiefly dependent on the mechanical condition of the coke used." This may appear to be a somewhat sweeping assertion, but I will endeavor to warrant it, subject to the reservation that the mechanical portion of the plant is in good average working condition. There is no doubt that the question of the mechanical condition of the coke is a very controversial subject, but it has not received in the past anything like the amount of attention and investigation that its importance in blast-furnace practice calls for, and it is with the object of calling attention to this lack of information on the subject that this paper is written.

I have ignored the mechanical and chemical conditions of the ores and fluxes, as, when making Cleveland iron, it will be agreed that there is practically no variation therein from one year's end to another.

The percentage of ash in the coke and the analysis of the ash are factors that are more variable, which affect the coke consumption per ton of pig iron and the quality of iron directly, but are capable of anticipation and calculation. The coke hardness is a thing apart, and in my experience can be treated as such, although I fully recognize that it has its chemical

actions and reactions to perform in the furnace, apart from its purely mechanical functions.

Since I shall frequently refer to the "hardness of the coke," it is necessary for me to explain the meaning of the term.

In 1909 we installed a machine which was called the coke tester, and which was originated, I believe, by Mr. Greville Jones of the Clarence Ironworks, Middlesbrough. As a practical experiment it was a success, inasmuch as we were enabled to say whether a coke was good, bad, or indifferent, from the hardness point of view, for utilization in the blast-furnace.

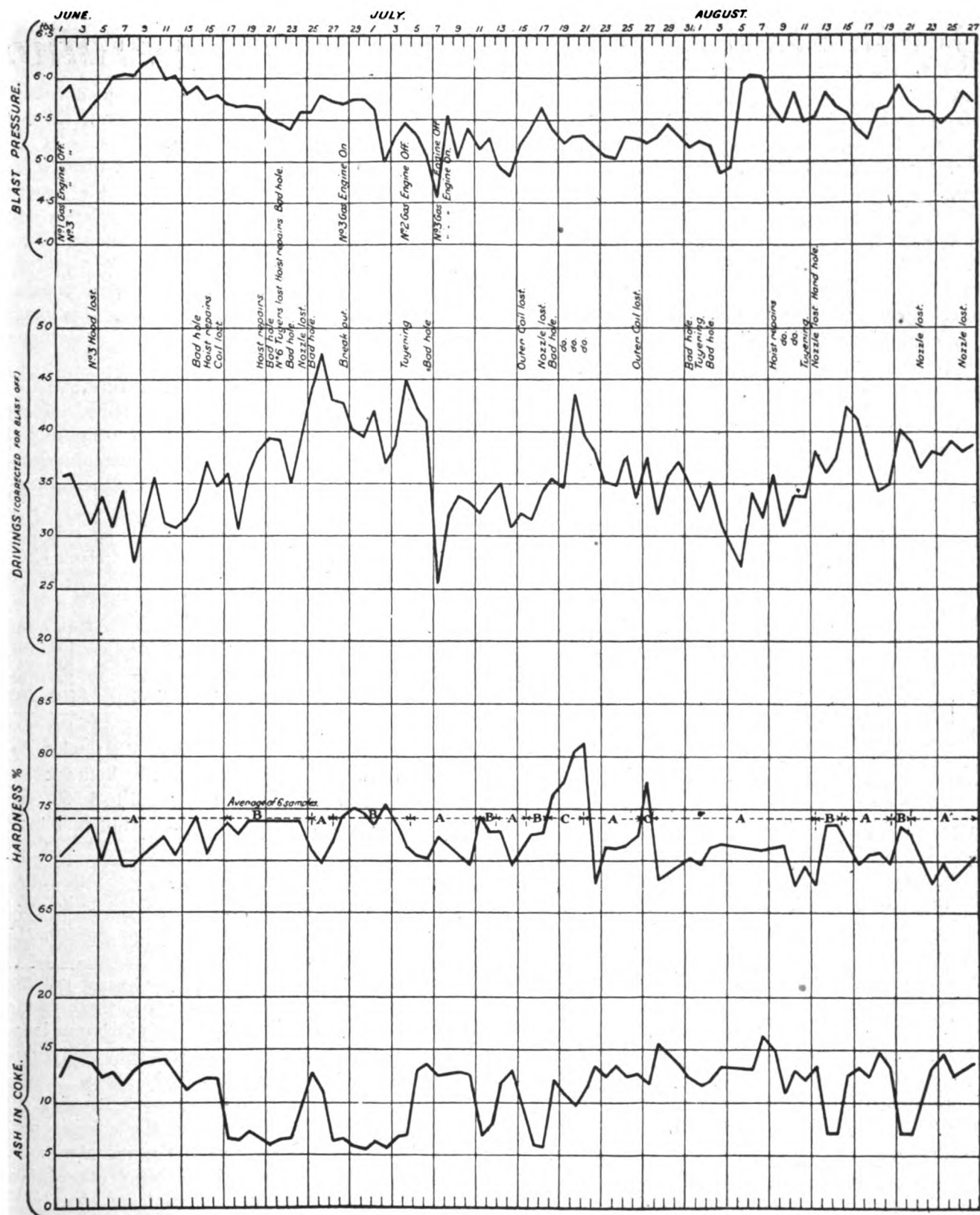
The machine consists of a drum which is made to revolve at 18 revolutions per minute, with two angle-bars fixed inside to turn the coke over; there is also a hand-hole for insertion and extraction of the coke sample, and an indicator to note the revolutions.

To make a test for hardness a sample of coke is taken of about 56 lb. weight, consisting of lumps up to the size of one's fist, and dried on hot plates for 24 hours. Of this 28 lbs. are weighed out and placed in the drum, and the cover plate screwed down. The drum is then revolved for 1,000 revolutions at 18 revolutions per minute. The coke is next taken out and riddled over a $\frac{1}{8}$ -inch mesh, and that which remains on the riddle is weighed and the percentage of the original 28 lbs. noted. That percentage we call the "hardness" of the coke.

By this means, after a few months I had a good comparative record, and by closely watching and comparing the furnace drivings with the coke hardness, I found that there was a very close connection between the two. I need not relate the detail which was gone through to eliminate every possible cause that might have misled us into believing the variations in the drivings were caused by the coke when the source of trouble lay elsewhere; it is sufficient for me to tell you that every care and precaution were taken, and we were eventually convinced that the coke, and that alone, was responsible for the variations in the drivings.

The next item to determine was at what point on the coke hardness scale the drivings commenced to fall off; this was found to lie between 74 and 74½ per cent of hardness, and during the past eight years this has been proved correct on so many occasions that I do not hesitate to say that in connection with our own plant we know there will be slow driving and conse-

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quent trouble when the hardness falls below that percentage. It is therefore essential, if we require good steady driving, that the coke hardness should be over 74 per cent.

I have not been able to trace any additional advantage with coke of a higher percentage of hardness than 76 per cent, but on plants where a blast-pressure in

excess of 7 lbs. per square inch is used or available, it may be found that the benefits derived from a hard coke may accrue to a higher percentage than I have mentioned.

When the hardness falls below 74 per cent a very marked falling off in drivings takes place, and I find that the lower the percentage the worse are the driv-

ings. I have had the experience during the past twelve months of using a considerable quantity of coke which has only averaged 70.5 per cent of hardness, and I estimate that as a direct result the drivings of the blast-furnaces have fallen 20 per cent. I do not, however, care to state definitely that percentage as due to mechanical troubles with the blowing plant, the blast has been very variable, and it is extremely difficult to apportion the blame correctly, but from past experience I do not think I am far out in my estimate.

The attached diagrams of coke hardness and drivings which I kept for a few weeks last summer are extremely instructive, and illustrate the immediate increase of drivings which follows on the charging of a hard coke; there is nothing of which I know that appeals to the eye and the brain so readily as a diagram such as this, and I place a great deal of confidence in it to support my axiom that "The practical success of the working of a blast-furnace is chiefly dependent on the mechanical condition of the coke used."

It is unfortunate that the period covered by these diagrams should have been one in which the blast-pressure was very variable, and I think I should call attention to the fact that the blast-line shown is only the average for the 24 hours, and consequently does not indicate those periods during the daytime when the pressure sometimes fell to 3 lbs. and even less for four or five hours at a time.

The drivings are corrected for the time the blast was off the furnace each day—that is to say, if the blast was off for one hour and the drivings were 30 for 23 hours, then $30/23 = 1.3$ rounds per hour, therefore 30 plus 1.3 = 31.3 rounds for 24 hours. The hardness percentages are the daily tests and represent one sample only per day. There were three different cokes used during this period, marked A, B, and C; the B coke has a very low percentage of ash, and although not hard is less friable than a coke containing a higher percentage of ash, owing to it not being so much split up by small pieces of stone, consequently it acts up to a point in the same manner as if it were 1 or 2 per cent harder.

Another point I wish to mention is that with a 76 per cent hardness coke, and an average ash contents of 12.5 per cent, the daily drivings of the furnace to which these diagrams refer is 48 rounds per 24 hours, with no allowance made for blast off, but with a pressure of $6\frac{1}{2}$ lbs. per square inch.

It will be noticed that although the diagrams are chiefly below par, i.e. 74 per cent, immediately that critical degree of hardness is passed a marked improvement in the drivings is immediately indicated, in spite of outside adverse factors appearing here and there.

I have now stated roughly the general effect on a blast-furnace when using hard and soft coke. When

the former is used increased drivings give greater output and, conversely, when the latter is used reduced drivings mean a smaller make.

This leads naturally to the question of coke consumption, and I will now attempt to show the advantage of hard coke in this respect.

When coke is charged into a blast-furnace it immediately comes into contact with the ascending gases, which act upon it in a greater or lesser degree, dependent upon its mechanical condition and the temperature of the gases.

Many experiments have been carried out in the laboratory with a view to illustrating this reaction, and it has always been found that the gases have far less effect on hard coke.

Bell, in his book on the "Manufacture of Iron and Steel," gives the following experiments, which indicate a serious loss of carbon when using soft coke:

"Trials of coke from two different collieries—the one being of known inferiority to the other—for decomposition of CO_2 .

"The specimens were exposed side by side for different periods of time at a temperature of about 1,500° F.

Exposure Hours	Average of	Percentage of Loss.		Ratio of A to B
		A (better quality)	B (second quality)	
2	3 samples	1.097	2.257	100 205
4	3 samples	1.903	3.767	100 198
6	2 samples	2.904	5.645	100 194
8	1 samples	3.893	7.801	100 200
				Average 100 199

"These trials therefore indicate that while a ton of coke in the case of A would in two hours lose 0.778 cwts., the waste on B would be equal to 1.560 cwts.

"A second series gave the following results:

Exposure Hours	Average of	Percentage of Loss.		Ratio of A to B
		A (better quality)	B (second quality)	
2	2 samples	0.758	2.274	100 300
4	2 samples	1.356	3.152	100 233
6	2 samples	2.674	5.766	100 215
8	2 samples	3.892	7.802	100 200
				Average 100 237

"Both sets of figures indicate that the better quality coke continued at the end of eight hours less susceptible to the action of hot carbonic acid than the other with which it was compared."

In another part of the same work he says: "The mechanical texture, however, of the coke is perhaps more important in the eyes of the furnace managers than any trifling increase in the percentage of ash;" also, "In addition to the experiments already given specimens of coke were exposed at a bright red heat (1560° F. to 1580° F.) for the same time to the action of a current of carbonic acid. In the case of the soft coke 18.7 per cent of the carbon in the carbonic acid was reduced to the state of carbonic oxide, while in that of the hard coke the proportion of carbon so altered was only 7.3 per cent of the total quantity."

(Continued on page 512)

Principles of Open Hearth Furnace Design

Actual Calculations and Principles Involved in the Design
of Open Hearth Furnaces—Pressure in Furnace—Port Ends.
Ratio of Air to Gas Passages—Flue and Valve Diagram.

By CHAS. H. F. BAGLEY.

PART II.

Before proceeding to the subject of combustion and volumes, it is well to consider the conditions of pressure existing in the furnace, flues, and valves, etc., and the forces behind gas and air, and in the chimney. The incoming gas will usually have behind it an initial pressure of 1 to 2 inches, w.g., but is reduced by the regulating valve to suit the requirements of the furnace; while behind the incoming air there is only the difference in density between two columns of air of atmospheric and regenerated temperatures respectively, and of height equal to that between the bottom of the chequer chambers and the level of the air port. The effective height of the chimney should be measured from the level of the ports, and its pull considered as being exerted at the face of the ports. The pressure in the body of the furnace must necessarily be atmospheric and approximately balanced; for the velocity of gases under the slightest suction—or pressure—is such that, if not, there must be an enormous inrush of cold air or an equally large outburst of flame at every door and crevice. The incoming gas and air must therefore be considered as being delivered under slight pressure through large orifices into an open space, combustion taking place under constant (atmospheric) pressure, and the flame and waste gases traveling freely down the furnace until they come within the influence of the chimney draft near the face of the ports. Thereafter the waste gases are under a slight negative pressure, and will expand in volume accordingly; but throughout the differences in pressure vary so slightly (rarely more than 5 mm. Hg., or 0.66 per cent.) from the atmosphere that their effect on volumes is almost negligible, and especially so when compared with the variations due to differences of temperature at various points in the circuit. Thus all questions of areas are mainly dependent on temperatures rather than on pressures at different positions. The diagram (Fig. 1) clearly illustrates the points.

It should always be remembered that the amount of gas admitted to the furnace is, and must be, regulated at the inlet valve to suit the requirements of the furnace; and the air should be regulated to suit the gas supply. In practice, however, the usual difficulty is to get sufficient air supply to consume the gas available, the gas being under a positive pressure. Hence the

Second installment of paper read before British Iron and Steel Institute.

prevailing custom is to open the air valve to its full and to regulate solely on the gas valve. Deep chequers are therefore necessary, not only for high initial temperatures, but also to ensure an ample supply of hot air to the furnace, without which full use cannot be made of the gas available. The chimney height should be increased accordingly.

The actual pressure at different points can hardly be foretold under such conditions; but it is often useful to have a pressure diagram—taken when the furnace is in good condition and working well—as a basis for comparison with conditions prevailing towards the end of its life. Without a standard for comparison, such diagrams are of little value; and the author prefers a

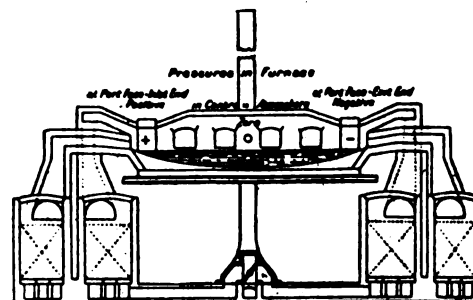


FIG. 1.—PRESSURE DIAGRAMS, ETC.

Supply Conditions.

Gas pressure in main = say, 2 in w.g.

Air pressure at valve = atmosphere.

Draft at chimney base = say, 1½ in.

Gas Pressure—

In flues = supply pressure subject to valve regulation.

At port = supply pressure, plus pressure equivalent of height.

Air Pressure—

In flues = atmosphere subject to valve regulation.

At ports = atmosphere plus pressure equivalent of height.

Suction—

In flues = chimney draft, subject to damper.

At ports = chimney draft, less pressure equivalent of height.

diagram of temperatures at the corresponding positions—always taken, of course, at the same stage of the process (say just before tapping and just after reversing).

Pressures should be taken on the incoming end: (1) At the valves or in the flues before entering the chequer chambers; (2) in the slag pockets or chequer chambers after regeneration; (3) at the top of uptakes (virtually in the ports); and at the corresponding positions on the outgoing end—care being taken to note the difference between positive and negative

pressures. The initial pressure in the gas main, and the maximum draft at the chimney base, should also be noted; the furnace should then be reversed and the readings repeated.

With the temperature diagrams there is no question of positive and negative results. The readings should be taken in the same positions, but care should be taken that the furnace conditions are the same, and that the furnace has been working the same length of time on each end. The relative volume of air, gas, and waste products passing at any point is mainly affected by their temperature variations (which are considerable), rather than by their pressure variations (which are comparatively small), and their velocities are proportional to the volume passing divided by the sectional area at that point, subject, of course, to fric-

but the question of proportions to be taken by each will be determined by other considerations. It may be noted here that when these proportions are desired, they can be permanently and automatically secured—without the aid of dampers on every chimney flue (which would be extremely difficult to regulate accurately)—by simply proportioning the chimney flues, desired to draw through gas and air chambers respectively. The author has always considered this one of the most important and least considered points in the whole design. The usual practice is to “make them big enough,” regardless of relative volumes or other reason—with various results in the chequer-work and on the initial temperatures of gas and air—all resulting in loss of flame temperature and efficiency of furnace.

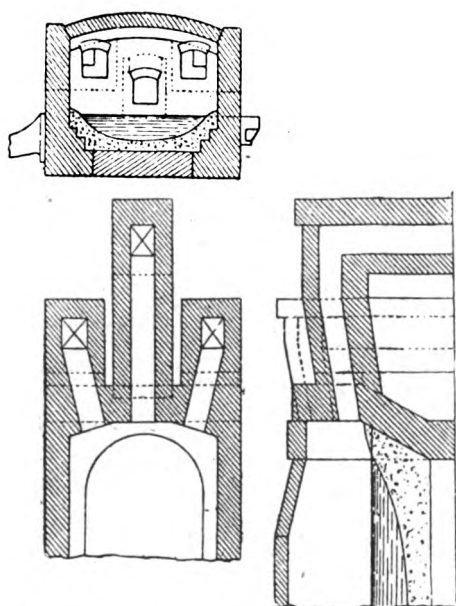


Fig. 2—A—Three-part design with air cooling.

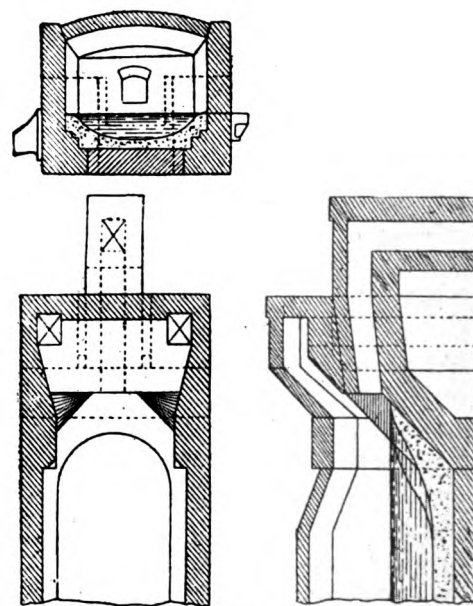


Fig. 2—B—Overhead air port design with air cooling.

tional losses. Given their initial volumes and temperatures, and the subsequent temperatures at different positions, it is possible to calculate the areas so that the velocities will be approximately constant throughout. The volumes entering are, however, subject to control at the inlet valves, and the volumes delivered into the combustion chamber are limited by the area of the discharging orifices (or ports). Between these two points, sectional areas may be anything desired, provided not less than the ports, and may therefore be determined by other considerations. So also as regards the outgoing end—the flow of waste gases is subject to control by damper in the chimney flues, and to the inlet area at the ports; and the sectional area at any point between may be anything desired, provided not so small as to check the even flow between the valves, to the volumes of waste gases it is between these two points. The gas and air port areas (and chimney flue areas) must be taken together as regards the total volume of waste gases to be passed;

Port Ends—The respective merits of different types of port ends are much disputed questions, particularly as between the two standard types, (1) the solid block with two air ports (Fig. 2a), and (2) the open block with a single overhead air port (Fig. 2b); and it seems to remain purely a matter of opinion and of correct detail, to the absence of which so many failures are attributable. Type 2 is generally regarded as the keener and faster working design, and allows a short length of combustion space before the hearth proper is reached, and, of course, removes the block so much farther back on the outgoing end, thus reducing the chance of “burning” it. On the other hand, it is the weaker structure and requires more careful designing or the gas port is liable to lose its shape and throw the live gas on to the linings. Its natural tendency is to spread the flame and keep it down (whereas the opposite is the case with the three-port type), and a wider furnace is desirable for this type. The three-port type, though slower-working and allowing no

preliminary combustion space, is said to stand up better, though it has to stand the direct heat of the outgoing gases, and is liable to get "burnt" unless the gas supply is closely regulated. No great care is needed in design or building; there is less chance of burning the side walls (though more of the roof), and there is no brickwork subject to heat on both sides without cooling surface, as in the case of the arch between gas and air ports in Type 2. On the whole, there seems little to choose, though personally the author prefers the keener furnace. These remarks apply equally to tilting furnaces, but the necessity of movable port ends rather complicates the matter. In Type 2 the joint between furnace and port ends is made at the face of the block, the furnace end being open, and the ports built in a single solid block outside—which, of course, is a great weight. In the three-port type the joints are made in the ports themselves, the block face remain-

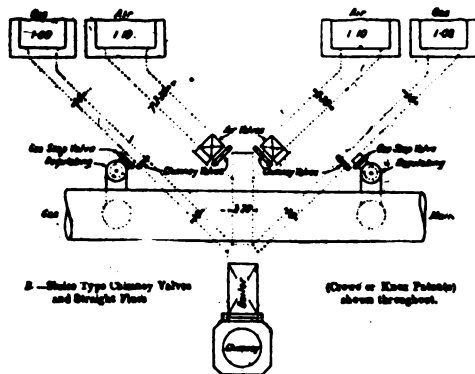


Fig. 3—Flue and Valve diagram.

ing in the furnace proper. By this arrangement it is possible to build the movable ports in three separate sections, none of them very heavy, so that they can be lifted and taken away by the overhead crane and a spare put back in their place. The repairs can then be done later when cold, and the week-end repairs are very much reduced.

By careful design it might be possible to build a block of Type 2 in a single piece so light that it could be handled and changed by the overhead crane as the individual ports of Type 1 are—which would greatly simplify matters and yield the advantages of both. One of the advantages of a tilting furnace is the facility of getting at the ports for repairs at the weekend.

Ratio of Air to Gas Passages.—So far as supply to the furnace is concerned, and subject to regulation by the valves, the intake areas, flues, etc., may be in the ratio of 168/208, or 0.80 air to 1.00 of gas, and the chequer chambers, uptakes, and ports, in the ratio of 887/555, or 1.60 air to 1.00 of gas. It is, however, more important to arrange for the proper distribution of heat between the chequer chambers in such proportion as to maintain an equal temperature on both gas and air when the furnace is reversed. This is dependent

on the amount of heat to be imparted to gas and air respectively—which thus takes account of their initial temperatures and relative weights—neglecting differences in specific heats. These weights were found to be 116.7 kg. of gas to 205 kg. of air, entering at initial temperatures of 300 deg. and 15 deg. C. respectively; and both are to be raised to 1,250 deg. C. by the regenerators. The heat units absorbed in so doing will therefore be in the ratio of $205 (1,250 - 15) = 254,000$ by air, to $116.7 (1,250 - 300) = 110,800$ by gas, i.e., in the ratio of 2.30 by air to 1.00 by gas, and the volumes of waste gases passed through air and gas chambers respectively should be in the like ratio—2.30 to 1.00.

To effect this distribution with the same chimney draft in the flues and at the face of either port, the areas of air to gas passages, ports, and flues must be in the same proportion (see Fig. 3), which differs considerably from that required for the incoming gas and air. There are thus two conflicting conditions as regards ratio of port and flue areas, of which the proper distribution of the waste heat is more important; for the incoming volumes can be controlled at the valves. Areas should be fixed accordingly, and the proportion maintained throughout to ensure the even flow of waste gases throughout. The author considers it important to aim at an even flow of gases, and to avoid abrupt changes of velocity as far as possible. It was previously pointed out that sectional areas between ports and flues may be anything desired; but the only place where he considers it desirable to alter this proportion is in the width of the chequer chambers, by manipulation of the chequerwork, where the ratio may be halved to advantage as regards the general design of the furnace, without affecting the balance in any other way. Variations from the data and assumptions, gas analysis, excess of air, moisture, temperatures, and pressures, etc., will affect this ratio to some extent, but it will usually remain between 2.00 and 2.50 to 1.00.

N. B.—The gases arising from the oxidation of carbon in the charge have not been taken into account, as they will rarely exceed 1 per cent of the total volume of waste gases passing out at, say, 1,500 deg. C. The effect of poor gas is to decrease the ratio of air to gas passages, that of richer gas or excess air, to increase it.

In designing an actual furnace there are two leading dimensions required as a basis, viz.: gas-port area and hearth area per ton of steel capacity, from which the rest may then be calculated. These data are best taken from practical experience with successful furnaces, but with due regard to other working conditions; for practice and circumstances are very variable in both respects.

In the next installment of this article heat area, gas port area, uptake, slag pockets and bridge arches, checker chambers and chimney flues will be discussed.

Physical Reconstruction of Crippled Men

Plan of United States Government for the Rehabilitation and Vocational Training of Crippled Men Aided by Red Cross—Schools Established Giving Courses in Oxyacetylene Welding, Etc.

By CONSTANCE DREXEL.

"I don't mind dying for my country," is the thought in many of our brave boys' minds—"but, oh, kill me rather than leave me disabled the rest of my life," they inwardly plead.

Small wonder, for they remember the cripples of old peddling pencils or shoestrings down the street, or even worse objects of charity and pity. They know of the thousands of men disabled in industry every year protected by a compensation act, perhaps, yes, but thrown out on a cold, unfeeling world to live a life of uselessness the rest of their days.

But times have changed. No need for our boys to worry, or their families to wonder who will care for them in case they come back from war with loss of arm or limb or worse.

Uncle Sam has stepped in. In fact, the problem is occupying a great deal of attention at the office of the surgeon-general of the Army, supplemented by all the Red Cross can do to help. The Red Cross is paying for the publication of "Carry On," that able magazine the surgeon-general's office is getting out on this very subject. It is free to those interested. "Carry On" is its message, "let there be no more cripples after this war." The Red Cross is also issuing pamphlets of information free, in the effort to popularize this new attitude toward cripples, that we are not going to have any more cripples in America either from the war or from injuries received in industry.

To prove that this can be done, the Red Cross maintains in New York at 311 Fourth avenue, the Red Cross Institute for Crippled and Disabled Men, the head of which is Dr. Douglas C. McMurtrie, a pioneer of this new attitude of society's duty toward a disabled man. At the school six model courses are given to refit crippled men for their old or new trades. The six courses decided upon are: Manufacture of artificial limbs; oxyacetylene welding; mechanical drafting, printing, motion picture operating and jewelry work.

Briefly, the plan of the United States government for the rehabilitation and vocational training of men crippled through this war is this: Even in our hospitals in France, convalescent men are shown moving pictures of successful cripples; Thomas Edison, nearly stone deaf, for instance; Michael Downing of Minnesota with both legs, one arm and one hand gone,

president of a state bank, running his own motor car and a lucrative law practice to boot, married and raising a happy family.

But the work really begins in this country. Upon arrival in the great military hospitals under the medical branch of the army, even while still in bed, the process of refitting them to normal life and responsibilities begins. I saw wounded from overseas at Walter Reed Hospital, in Washington, being taught by reconstruction aids in occupational therapy. Some were busy with basketry or weaving, but others were doing head work. I remember one man in bed, one leg off, studying shorthand. When the men become able, they are sent from the wards to the finely equipped new buildings known as the curative workshops. Here are classes in motor mechanics, very popular, use of the left arm and hand instead of the right, classes in English and French, in shorthand and typewriting for cases of amputation of legs, telegraphy, rug weaving, artificial limb making, carpentry, agriculture and farming. Of course, the aim of these classes is to cure the men physically as soon as possible, but even here their vocational training to fit them for their future place in the community may begin. The men who have lost arm or leg, or have been otherwise disabled, are talked to by experts who try to guide them to refitting themselves for usefulness.

And after the medical authorities can do no more for the crippled man, after they have done all they could to make him as near whole again, including the providing of artificial arms or limbs, even then the United States government does not pretend to end its responsibility. Congress has created the Federal board for vocational education. Theirs is the official responsibility for the re-education of soldiers and sailors of the American forces disabled by the war. A fully definite program has not yet been developed, but the Red Cross Institute for Crippled Men already mentioned has demonstrated how the thing can be worked out. Crippled men have been taken off the streets, trained in one of the six trades taught there and placed in lucrative positions where their infirmities are no handicap.

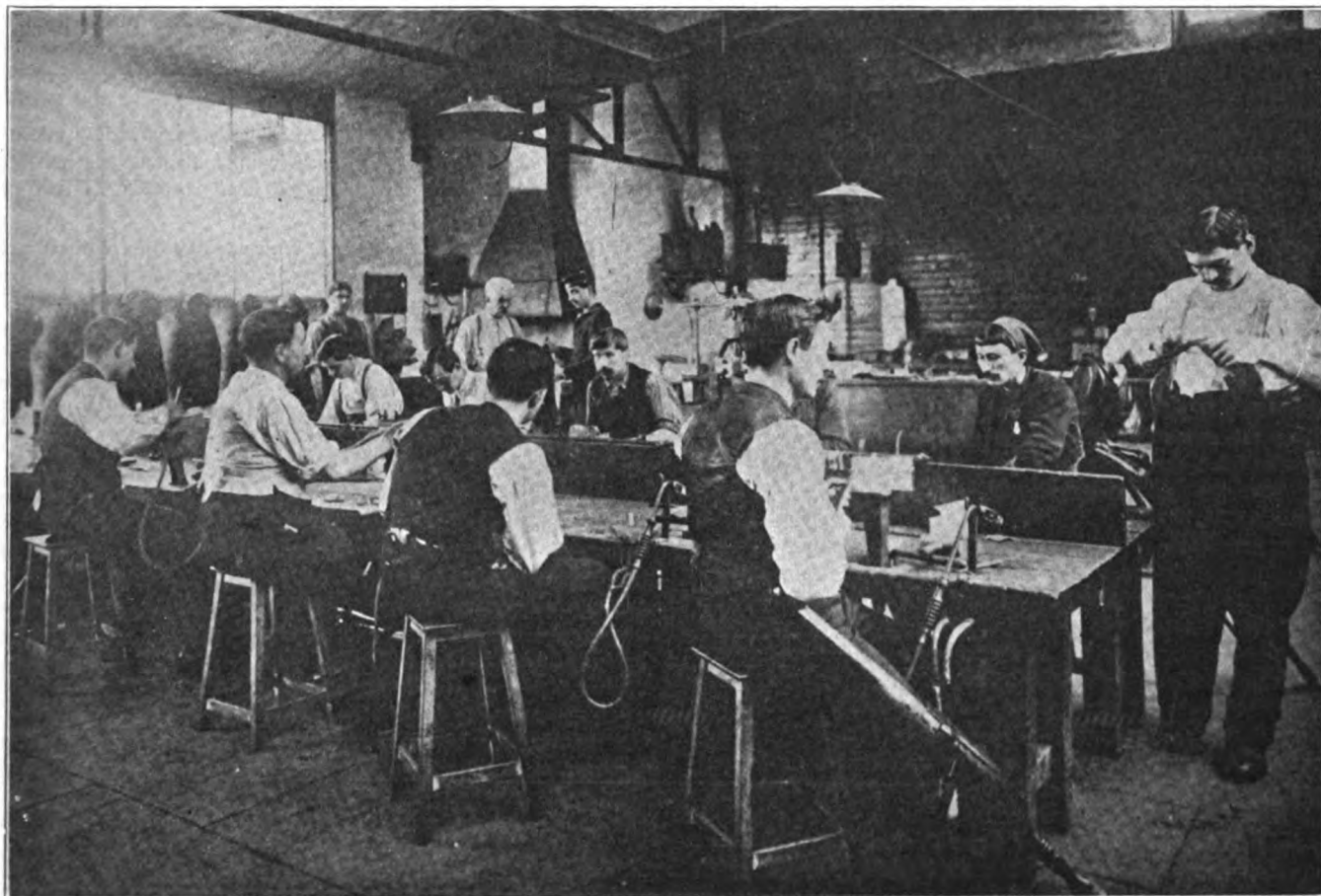
As for soldiers to be refitted to civilian life, a former brakeman on a railroad has lost an arm. He can't be a brakeman any longer, but his railroad knowledge can be of use to him. He is trained to become an expert telegrapher or train dispatcher. What

difference in his productive ability to a soldier fitted with one or two artificial limbs if he sits at a linotype machine all day? If he has been formerly employed at a standing job in a printing or newspaper plant that experience can be turned into good account. The point is here, that a disabled man need not necessarily be trained to an entirely new trade. His former experience should be made to count.

However, details of the re-educational and vocational program are not nearly so important to the working man, be he in the army or in industry (for in either case he is liable to be hurt), is the attitude army

the pension will be granted regardless of a man's earning capacity that he develops in spite of his infirmity. If he does what the government and the Red Cross want him to do—refit himself to a job—he will have the pension just the same. This proves that the working man is going to be very important. We shall need all that every man can produce; the more they produce, the cheaper will living expenses become. Therefore, no idlers, no more cripples.

As the Red Cross is heart and soul back of this idea, it would seem that for his own good in industry the working man should at least become a member of



Crippled French soldiers being trained to take a place in industrial life.

authorities, supported by the Red Cross, have assumed toward crippled men.

No longer will the responsibility of army or government or industry cease by merely pensioning a man. He must, and will, be refitted to retake perhaps even a better place in the community than he had occupied before his injury. For are not brains worth more than hands or feet or even eyes? And should not a physical handicap, if properly encountered, be used to develop the brain to greater action?

Here, however, it must be pointed out, that Uncle Sam intends pensioning generously all disabled soldiers or sailors \$100 a month, or \$1,200 a year, for life in many cases. But, and this is an all-important fact,

the Red Cross. Anyhow, he'd be most welcome. There'll be a roll call of the nation at Christmas time, when it is hoped all will answer "Here!" The membership cost is only \$1 a year.

Thus far the attitude of organized labor toward the cripple has been most admirable, and it is safe to assume no friction will ever arise in labor unions or among workmen by reason of the induction of this new class into the ranks of labor. Labor has already spoken on the subject and what it has said is to its credit. Every re-educated cripple, able to produce, is not only made happy by earning his own living, but is adding to the sum total of the nation's productivity. The work of training the crippled soldier is, therefore, of great importance.

PRODUCTION TOPICS

RECONSTRUCTION OF FRENCH IRON AND STEEL INDUSTRY.

Under the name of "Société Corporative des Mines de fer et de la Sidérurgie des régions sinistrées" a company has recently been formed in France for the purpose of conducting commercial or industrial operations useful in bringing about the reconstitution and reorganization of the iron mines and steel works of the invaded regions.

The company is affiliated with the Comptoir Central d'achats industriels pour les régions envahies, and has its offices with that organization at 40 rue du Colisée, Paris. The new company is practically a technical commission of the Comptoir Central. For convenience, however, a separate share company has been organized. Its capital stock of 1,000,000 francs, divided into 2,000 shares of 500 francs each, is held by iron mining and steel companies owning properties in the invaded regions of France.

The society is administered by a Conseil d'Administration (corresponding to the board of directors of an American corporation) composed of not less than 10 and not more than 25 members elected by the shareholders.

The new company is making estimates of the raw material and equipment that will be needed to restore the damaged iron mines and steel works in the northern and eastern part of France. Its method is to gather the best information available regarding the extent to which iron mines, blast furnaces and steel works have been destroyed, and on the basis of this data prepare purchase programs covering the materials needed for replacement.

These programs, when approved by the directors of the Société Corporative des mines de fer et de la Sidérurgie, are turned over to the Comptoir Central d'achats for execution.

It will not be possible to gain an accurate idea of the quantity or the value of raw materials and equipment needed to restore the iron and steel industry of the invaded regions until the Germans have completely evacuated the Lorraine sector.

In 1913 France produced 21,714,000 tons of iron ore, of which 19,800,000 tons (or 90 per cent) came from the one department of Meurthe et Moselle, in which the iron basins of Nancy, Longwy, and Briey are located. The last two regions, which furnished the great bulk of France's iron ore, have been in the occupation of the enemy since the beginning of the war.

Of the 5,300,000 tons of pig iron produced in French blast furnaces the year before the war broke out 86 per cent came out of the blast furnaces of the north and east.

Much of the special equipment needed in the restoration of the French iron mines, blast furnaces, and steel works will have to be furnished by the United States.

FUEL ECONOMY IN THE ANNEALING FURNACE.

The advances and technical developments which have been made in England during the war are of considerable significance. The following from the *Iron and Coal Trades Review* contains some points of interest regarding heat furnaces.

"During the past few years there is perhaps no form of apparatus in which such revolutionary changes have been made as in the design of heat-treatment furnaces. On the whole, it is in the gas-fired furnace that the greatest change has taken place. Indeed, the modern gas-fired furnace has few if any features in common with its prototype of pre-war days. Its construction has been simplified and its operation brought within the capacity

of the semi-skilled laborer. Its economy and efficiency have little to be desired, while the maintenance costs have been reduced to the narrowest possible limits.

"With hard-fuel furnaces the changes have not been so drastic, perhaps because there was not so much room for change and improvement of a radical nature, as the design of this furnace has been evolved over a long period of years. The modifications which have been recently effected have therefore for the most part resulted in an indirect rather than a direct economy, by simplifying the operation, reducing the time required to obtain the desired temperature, insuring a more uniform temperature throughout the chamber, and by a more robust form of construction considerably extending the useful life of the furnace.

"While the gas-fired furnace has been very widely adopted, it has not and probably never will wholly displace the hard-fuel furnace, which for many forms of heat-treatment is still preferred.

"On a recent visit to a South Wales works our representative had an opportunity of inspecting a battery of eight coal-fired furnaces with chambers 12 by 5 feet, which are in service for heating and annealing metal blanks during the various processes of manufacture. It is claimed that these furnaces give better and more economical results than was possible with gas-fired furnaces, and the assertion was also made that the heat with the coal-fired furnace is more soaking.

"The furnaces were built by Messrs. Curran Brothers, Hurman street, Cardiff, Wales. This type of furnace has already been described; the installation in question, however, embodies an important modification. The products of combustion, instead of passing direct from the furnace chamber to the waste flue, are led over the furnace chamber down vertical passages at the back end, and thence through longitudinal chambers beneath the furnace floor to the front of the furnace through similar chambers to the back, and again through a third series of chambers to the waste-heat flue which is placed at the front of the furnace chamber. Practically the whole of the sensible heat is absorbed in the first series of chambers, and is thus given up to the furnace floor by radiation; the little heat remaining in the gases passing into the third series of chambers is absorbed by the walls of the first series.

"The fuel consumption, for a temperature of 750 degrees, is approximately 1,100 pounds per 24 hours. It is, however, more usefully interesting to consider efficiency and economy over a reasonable period under ordinary every-day conditions, which in the case under notice we are able to do. Thus 2,540 heats were taken out of the furnaces with an expenditure of 202,400 pounds of coal. The coal consumption includes banking down for 24 hours at the week ends and picking up. The weight of metal per heat ranged from 2,500 to 3,000 pounds, and the pans from 1,800 pounds to 1 ton."

MICA SCHIST FOR FURNACE LINING.

The mica, to which the softness of mica schist is due, successfully withstands a very high temperature, and as the stone can be readily cut into blocks of the desired shape, mica schist has been used considerably as furnace lining. According to the United States Geological Survey, the quantity of mica schist produced in the United States for this purpose in 1917 was 39,975 short tons (of 2,000 pounds), an increase of 6,739 tons over 1916.

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NEWS OF THE PLANTS

The Milliken Brothers Mfg. Company, Inc., Woolworth Building, New York, has purchased the plant of the James H. Young Stone Company, One Hundred and Thirty-sixth street and East River, New York, for its proposed new steel works. The present building consists of a one-story structure, about 101x350 feet, providing over 35,000 square feet of manufacturing area. It is proposed to equip the new plant as a complete steel fabricating works for the production of steel transmission towers, radio towers and poles, as well as the standardized truss unit system of building construction which is formed of a simple common unit of structural shapes. Attention will also be given to plain and galvanized steel shapes, angles, etc. The plant is provided with an overhead electric traveling crane, as well as other modern handling equipment. An adjoining site of land has been secured, making a total of about two acres of property with water and rail facilities. On this latter ground, it is planned to build a modern galvanizing plant for the handling of structural shapes used for the construction of transmission and radio towers. Plans for this new building are now being considered, and estimates made of equipment to be installed in the new steel fabricating works. C. T. Clack is president, and J. E. Jennings, vice president and secretary.

Plans are being considered by the Algoma Steel Company, Sault Ste. Marie, Ontario, Canada, for extensions and improvements in its works to cost about \$800,000. It is understood that an appropriation of this amount has been approved in connection with the general plans for expansion. A large portion of the fund will be used for the erection of a new battery of coke ovens, with auxiliary equipment, and a number of new gondola cars for ore mine operation will be purchased. J. Frank Taylor is chairman of the board of directors and president of the company.

The plant represents an investment of over \$1,000,000. It is understood that this plan for plant conversion will include the operation of the works under the name of the Bethlehem Steel Corporation.

S. F. Novotny, president of the Manganese Mining & Development Corporation, Mena, Ark., is said to be organizing a new company for the construction and operation of a local blast furnace. J. B. Brimm is interested in the new organization.

Revised plans, it is understood, are being considered by the Ordnance Department, Washington, D. C., for the new government ordnance works to be located on Neville Island, Pittsburgh. The works will be equipped to manufacture guns up to 18-inch caliber, as well as ammunition. The original estimate of cost for the works aggregated \$40,000,000, and extension plans call for an expenditure of \$60,000,000 additional, or a total of approximately \$100,000,000.

The United States Steel Corporation, 71 Broadway, New York, is considering plans for extensions to its Duluth, Minn., works, to cost about \$15,000,000. It is proposed to build a new tin plate mill, a sheet mill, nail and wire mills and other structures, the work to be inaugurated closely following the declaration of peace. Production at the new plant will be used primarily for Western and Canadian markets. It is said that the new works will provide employment for about 1,600 men.

The new shell manufacturing plant of the Laclede Gas Light Company, St. Louis, Mo., to be located at Manchester, a few miles distant, will consist of a main building, about

200x1,100 feet, with a number of auxiliary shop buildings. The structures will be permanent, built of brick and steel. This plant, erected in cooperation with the government, will specialize in the production of 240 mm. shells, and is estimated to cost about \$1,000,000.

The National Steel Producing Company, Bessemer, Ala., is making rapid progress in the erection of its new steel plant, and it is planned to place the works in operation early in the coming year. Construction has been commenced on the foundry, furnaces, and other structures, and plans have now been completed for the erection of a number of subsidiary buildings to compose the complete plant. The company has a capital of \$160,000. R. F. Bohanon is vice president and general manager.

The Anaconda Copper Mining Company, New York, has completed the construction of its new ferro-manganese plant at Great Falls, Montana, consisting of five furnaces. It is proposed to inaugurate operations for complete production at once. The new plant will have a capacity of 90 tons a day. Each furnace is 22x10x8 feet, inside dimensions, requiring about 4,000 horse power electric energy to operate. A furnace charge will comprise 500 pounds of manganese ore, 20 pounds of iron ore, 70 pounds of limestone, and 170 pounds of coal. The manganese ore will be secured from the company's property at Butte. The new plant will give employment to close to 90 men. E. S. Bardwell is in charge.

The Bethlehem Steel Corporation, Bethlehem, Pa., has commenced the erection of a new 60-inch universal plate mill at its Sparrows Point, Md., works. The new plant will be about 200x1,070 feet, and is estimated to cost close to \$1,000,000. Irwin & Leighton, North Twelfth street, Philadelphia, have the contract for erection. The company has blown in its new furnace A at the Steelton, Pa., plant, which has been in course of construction for some time past. The furnace is of the new improved self-feeding model, requiring considerably less labor to operate than the old-style furnace. It is the third such furnace to be installed at the plant. It is reported that the Bethlehem Loading Company, a subsidiary of the Bethlehem Steel Corporation, with shell-loading plant at Belcoville, N. J., is planning to convert the existing works into a steel plant following the close of the demand for steel shells.

Arrangements have been completed by the Domestic Coke Company, Fairmont, W. Va., for the construction of a new coke works to cost about \$3,000,000. The plant will be built in cooperation with the Ordnance Department of the government, and it is understood that the company will acquire full ownership at the close of the war. Contract has been let to the Koppers company, Pittsburgh, for the construction of a new battery of 60 coke ovens, with auxiliary by-product equipment to provide for the production of 13½ tons of ammonia sulphite and 450 gallons of toluol daily. Frank H. Ginn, Pittsburgh, is president of the company.

ANNOUNCEMENT.

On and after January 1, 1919, the Sanford-Riley Stoker Company and Murphy Iron Works, will combine their sales policies so as to render the greatest possible service to all customers. Offices will be located at Worcester, Boston, New York, Philadelphia, Pittsburgh, Buffalo, Cleveland, Detroit, Cincinnati, Chicago and St. Paul.

Some Pointers on By-Product Coke Oven Operations

COKE FACTORS AFFECTING FURNACE OPERATION.

(Continued from page 502)

It is therefore quite evident from Bell's writings that he was fully aware of evil effects of soft coke in the blast furnace, and gives that opinion great weight by the experiments just quoted.

Chas. Cochrane also refers to the importance of retaining as much as possible of the carbon in the waste gases in the form of carbonic acid, but does not directly mention it in connection with soft coke. He says:

"It will be seen how important it is, with regard to economy of fuel in a blast furnace, that we should insure the combustion of every unit of carbon, if possible, into the more highly oxidized gas called carbonic acid; and furthermore, when once burnt into carbonic acid, that we should never allow it to pass again into the condition of carbonic oxide, if such a step be preventable."

Again a soft coke is usually very friable, and unless the ovens are situated close to the blast-furnace, so that the minimum of handling is thereby assured, it usually reaches the furnaces in a much smaller form than is the case with hard coke, consequently a greater area is exposed to the action of the gases as soon as it is charged into the furnace. (I am, of course, referring to furnaces with comparatively small makes, as when a furnace is making 700 tons a day, as many are in the United States, a smaller coke is necessary, but it must still be hard.) Having therefore commenced its passage through the furnace in a small state, I think it is allowable to imagine it becoming very finely divided before reaching the melting zone, and in support of this theory I should like to tell you of my experience at the Ormesby furnaces.

Trouble had been experienced at one of the coke-oven plants from which our coke supplies came, and the coke that was being charged into the furnace was soft and friable, and altogether what I should term very bad indeed. The furnaces struggled along for a few days, gradually driving slower and slower, until the coke commenced to improve; but, owing to the poor coke, the drivings of one of the furnaces had become so slow that we feared she was commencing to hang, as we could not get the slag to run, so, taking out the front tuyeres, we blew forward for a while to try and clear the forepart. This solved our troubles, for on commencing to blow forward great clouds of fine coke-dust were blown out, and when this ceased the front tuyeres were replaced, and the furnace commenced to drive again quite freely and, with the better coke coming down, we had no further trouble with the drawing off of the slag. This has occurred more than once, and is just one more instance of the terribly bad effect of soft coke on the blast furnace. Although this may be an extreme case, it serves my purpose to show that a low coke consumption cannot be expected when the coke loses some 10 or 15 per cent of its weight within two or three hours of being charged into the furnace, and on arriving near the tuyeres is in the form of dust so finely divided that it actually obstructs the passage of the blast and the tapping of the slag.

On the other hand, when a hard coke is being charged, there is only a very small loss at the furnace top; the lumps of coke are larger and less friable, with the result that the burthen is kept open and the blast passes through the furnace with a minimum of resistance, so, when the coke reaches the tuyeres, there is a considerable body of carbon

left to be reduced by the blast, and the gases evolved therefrom are consequently operative on all the materials in the furnace from the tuyeres to the throat.

It is noticeable that when a soft coke is being used the waste gases are very rich in CO, and the ratio of CO to CO₂ by weight is consequently low, whereas when a good hard coke is being used the CO is less and the ratio consequently considerably higher. This is, of course, explained by the greater ease with which the CO₂ in the ascending gases attacks the carbon of the coke when it is soft, and which action the harder coke is able to resist in a much greater degree.

There is one other point about which I keep an open mind, and that is the crushing of the coke in a blast-furnace. It is obvious that hard coke will offer greater resistance to a crushing stress than a soft one, but Chas. Cochrane always said, when his huge furnaces were criticised and the possibility of crushing of materials was mentioned, that "The crushing effect in a blast-furnace can never be very great, owing to the fact that the theory of the angle of thrust is equally applicable to a blast-furnace as it is to a grain elevator."

I have now touched upon what I consider to be the chief points in connection with the hardness of coke, and over a period of some eight years I have been time and again convinced of the unique importance of the coke hardness.

If hard coke is sent to the furnaces from the coke-ovens the life of a blast-furnace manager becomes a pleasant thing, but with soft coke his life is not worth living. With the former one gets the furnaces driving freely, a low coke consumption, an even quality of iron with plenty of gas for stoves, boilers, and gas engines and to spare, and with the latter slow drivings, increased coke consumption, variable quality of iron, shortage of gas, and general trouble and discontent.

There are a thousand and one little points and details in connection with this subject which it is impossible to bring out in a short paper of this description, but all of which only go to prove more and more conclusively that if we wish to manufacture iron with the minimum of trouble and the maximum of economy it is on the coke the whole matter depends.

Since the blast-furnace manager in most cases is more or less in the hands of the manager of the coke-ovens, it behooves him to try and make the managers of coke-ovens produce and send him a hard coke.

Doubtless it can be done by "stamping," but there are not very many plants in this country that are fitted with that device, also I do not think it is necessary to produce a coke of greater hardness than, say, 76½ per cent for conditions such as I have taken as normal, although greater hardness means a larger margin of safety. Besides, I have used coke made from identically the same coal without "stamping," which has one day been excellent in every respect and a few days afterwards equally indifferent. It therefore appears to be chiefly a question of supervision, and I trust that this short paper of mine may attract the attention of the coke producers to the importance of hard coke for blast furnace work, for in that case I shall not have pleaded in vain that "The practical success of the working of a blast furnace is chiefly dependent on the mechanical condition of the coke used."

INDUSTRIAL RELATIONS

TRAINING FOR WOMEN.

Many of the women who apply for industrial work will be totally unfamiliar with factory work or the operation and handling of machinery, so that the matter of training becomes doubly important.

It will be necessary to organize a system of competent instruction, if the change to women employees is to be made rapidly and efficiently and the heavy loss in production, while they are learning, is to be reduced to a minimum. To be prepared, the preliminary work toward organizing a crew of instructors should be started as soon as it is decided to use women workers.

The instructors to be used should be selected from the fastest workers in the organization. The mistake, however, should not be made of thinking that any fast operator will make a good instructor. They should be selected for their ability to explain things clearly; for pleasing personality, tact, patience, sympathy and consideration for the rights of others; for ability at performing the tasks they are to teach, and wherever possible unusually masculine men should not be put in charge of instructing women.

One suggestion was that instructors be recruited from the women of a community who have shown executive ability, training them to in turn train others. Another good plan would be to let women work part time as a step toward training women who could be used as forewomen. Instructions should be given first by men, then by the women who become most proficient.

As studies of operations were the first step recommended in determining what work women could do, they can again be used for purposes of training to excellent advantage.

Another suggestion was to take care of industrial training of women workers through coöperation with the Y. M. C. A. and the Y. W. C. A.

Wages, Hours and Fatigue.

The matter of wages, hours of work and fatigue is most important in connection with the utilization of woman labor. It can well be said that the success or failure of the movement depends to a great extent upon what we do with reference to these things.

The answers with reference to wages narrowed down to the following: (1) Determine standards and pay according to performance; (2) piecework, with minimum wage guaranteed; and (3) weekly wage for a time, then piecework.

The principle "equal pay with men for equal work" was subscribed to by practically all who answered the questions. One replied "Leave it to the women," feeling that they were amply able to take care of themselves. Several felt that earnings in advance of those paid men should be offered to attract women workers and secure interest and coöperation. Some were of the opinion that while women should receive the same as men if they produce the same, they should receive less if they do not produce as much, but more if they can exceed the production made by the men.

All through the answers, it was plan to be seen that the feeling was—No exploitation of women—and one went so far as to urge that the government take steps to prevent any possible exploitation in the unorganized industries. Our review indicates quite clearly that organized labor has nothing

to fear from the manufacturing world as regards women in industry.

In analyzing the questions as to hours, rest and fatigue, the conclusions were: (1) No night work; (2) no overtime; (3) no Sunday work; (4) half Saturdays off; (5) an 8-hour day, some urging a 54-hour week; (6) a rest period in the morning, and in the afternoon, in addition to the lunch period, and varying from 10 to 20 minutes; and (7) experiments to determine rest periods and fatigue factors in work of a very fatiguing nature.

If a plant is not of a size that warrants retaining a doctor and dentist permanently, arrangements should be made with local practitioners to handle all plant cases or else several concerns can associate and retain one medical and dental staff. However, in this case employees will require additional time for medical attention and will lose that much more production.

Employers and employees should get together on the important matter of wages, hours and fatigue, and work out definite rules and procedure.

Working Conditions.

Another very important factor in connection with the utilization of woman labor is the matter of the conditions under which they work. Select the best of women, pay the best of wages and make conditions agreeable; if working conditions are not right, the result is bound to be both discontent and dissatisfaction.

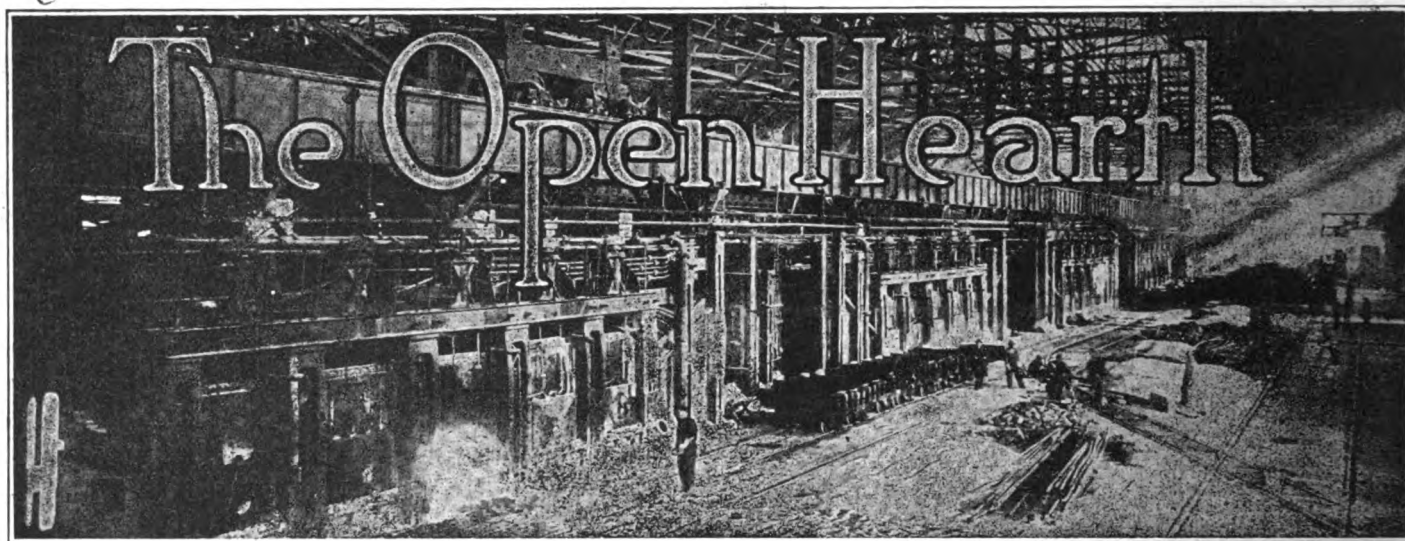
All workrooms should be thoroughly lighted; it helps the speed and accuracy of work. A generous use of white paint on walls and ceilings and even on machine bases, will accomplish wonders in improving the light and, next to this, clean windows are a great help.

With regard to ventilation, you will find languor, headache and a disinclination to work where the air is allowed to get stale. Fresh air should be admitted and bad air removed from rooms in such manner as not to create drafts. The temperature of the rooms should be kept constant. The best temperature to maintain varies in accordance with the strenuousness of the labor performed in the room.

The question of the position at work is especially important for women as their health and efficiency, are largely dependent upon it. Wherever possible their work should be arranged so they may be seated and the chair or stool designed so they will sit in an erect position. Where their labor requires standing a large part of the time, high stools can be designed on which they may rest in a semi-sitting, semi-standing position. Special attention should be given to arranging their work about them so that everything needed is within easy reach. This not only adds to comfort but greatly speeds up the performance of the operation.

Labor-saving devices should be installed wherever possible, to eliminate lifting and handling by women. Safety appliances should be given the most careful attention and rigid safety rules determined and maintained. Women should start on the lighter tasks and as they become proficient can take up heavier work, if physically able to do so. Under no consideration should women be placed at what might be called dangerous occupations. They should not be placed in departments where gas fumes or dust would prove detrimental to their health, nor should they be subjected to intense heat or cold.

Second installment of paper read by C. E. Knoepel and M. J. House, before American Foundrymen's Association.



At the organization meeting of the board of directors of the Crucible Steel Company of America, held November 21, the following officers were re-elected: Herbert DuPuy, chairman; O. H. Wharton, president; H. A. Brown, J. W. Dougherty, George W. Sargent, John A. Sutton and George A. Turville, vice presidents; George A. Turville, secretary and treasurer; A. A. H. Niebaum, J. M. McComb and H. F. Kress, assistant treasurers; N. W. Nolen, comptroller; G. A. M. King, auditor; H. H. Stewart and H. L. Gellinger, assistant auditors.

V V

Frank D. Carney, formerly superintendent of the Pennsylvania Steel Company, and general metallurgist of the Bethlehem Steel Company in connection with Lewis B. Lindemuth, formerly assistant superintendent of the Bessemer open hearth department of the Pennsylvania Steel Company and superintendent of the electric furnace and crucible department of the Bethlehem Steel Company, has formed a partnership of Carney and Lindemuth Consulting Engineers and Metallurgists, at 40 Wall street, New York.

V V

Ambrose N. Diehl succeeds the late Edward J. Hamilton as works superintendent of the Carnegie Steel Company. Mr. Diehl has recently been assistant to Wm. Whigham, vice president of the Carnegie Steel Company. Prior to that time, Mr. Diehl was superintendent of the blast furnaces at the Duquesne Steel Works.

V V

John E. Galvin has been elected president of the Ohio Steel Foundry Company at Lima, Bucyrus and Springfield to succeed the late Harry Wright. J. W. Kaufman is now chairman of the board of directors and J. T. Kaufman, secretary-treasurer. Frank Wright is first vice president and general manager and O. J. Smith, second vice president.

V V

John McConnell, for a number of years in charge of alloy and special steel production for the United Alloys Steel Corporation, Canton, Ohio, has resigned and assumed similar duties with the Interstate Iron and Steel Company.

V V

Wm. F. Cassidy, formerly foreman of the Ohio Steel Foundry Company plant at Springfield, Ohio, has been appointed general superintendent of the Aetna Steel Castings Company plant at Cleveland.

V V

Harry E. Higgins has resigned as director and vice president of the Otis Steel Company.

R. M. Rush has resigned as assistant district supply manager of the emergency fleet corporation for the Youngstown and Pittsburgh districts and will again assume his duties as district manager of the Kerr Turbine Company, and president of the Rush Machinery Company, Pittsburgh.

V V

S. R. Vanderbeck, S. H. Ourbecker and F. H. Shaw, all of whom were formerly connected with the Electric Furnace Construction Company, are now respectively, president, electrical engineer and purchasing agent of the American Metallurgical Corporation.

V V

H. F. Johnson has resigned as secretary to the superintendent of the open hearth works of the Republic Iron & Steel Co., Youngstown, Ohio, to join George W. Pepper, now general manager of the Donner Steel Company, Buffalo.

V V

Harry E. Blackwell has again assumed his regular duties as manager of the Detroit sales office of Pickands, Mather & Co. He has been working with the committee on Pig Iron, Iron Ore and Lake Transportation for the past four months.

V V

Willis Werner has been appointed chief chemist of the Republic Iron & Steel Co., Youngstown, Ohio, succeeding T. J. Davies. The blast furnace and open hearth laboratories will be in his charge.

V V

F. J. Ryan, formerly secretary, treasurer and general manager of the Electric Furnace Construction Company, Philadelphia, has resigned. He now assumes similar duties with the American Metallurgical Corporation, Philadelphia.

V V

H. M. Urban, formerly superintendent of the by-product coke ovens of the Tennessee Coal, Iron & Railroad Co., is now connected with the Woodward Iron Company, Woodward, Alabama.

V V

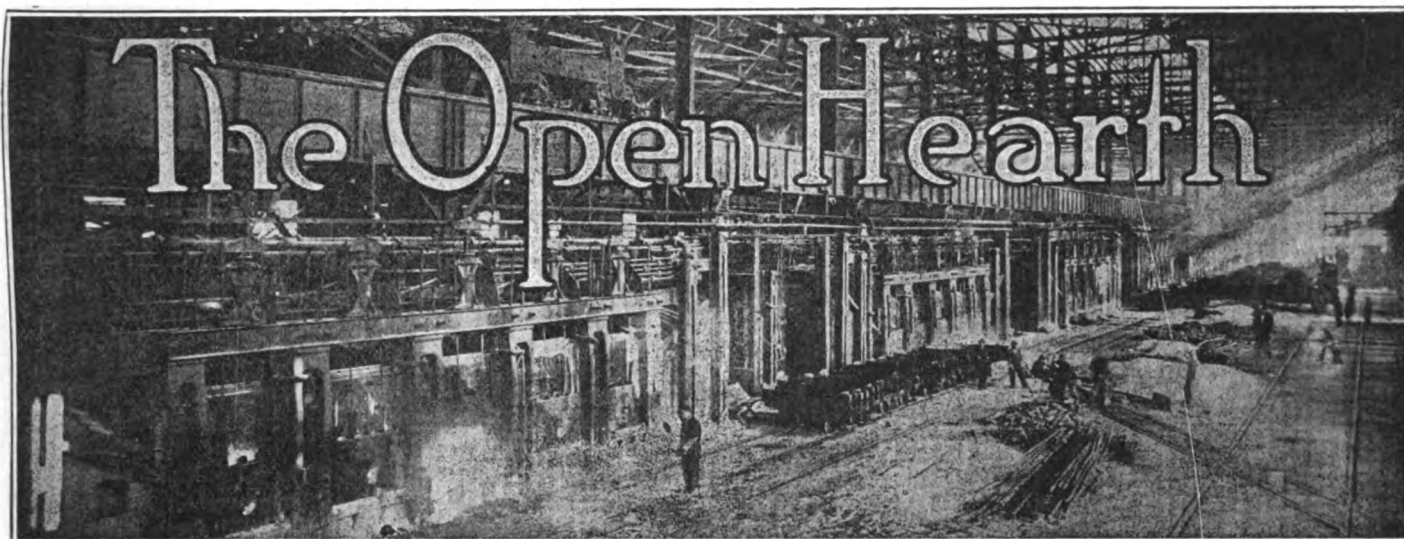
Thomas Chalmers has been appointed superintendent of the by-product coke ovens plant of the Tennessee Coal, Iron & Railroad Co., Birmingham, Alabama.

V V

David McLain, of the McLain System, Milwaukee, is now connected with the Ordnance Department, Washington, D. C., as foundry expert.

V V

E. I. Dennis, formerly associated with the Ferguson Steel and Iron Company, has been appointed manager of the Buffalo branch of the Latrobe Electric Steel Company.



J. W. Powell, vice president of the Bethlehem Steel Corporation, has been elected vice president of the National Society of Naval Architects and Marine Engineers.

✓ ✓

Wm. W. Lewis has resigned as superintendent of the Western Reserve Works of the Brier Hill Steel Company, Warren, Ohio.

✓ ✓

Abner Hughes, formerly assistant superintendent of the Western Reserve Works of the Brier Hill Steel Company, is now superintendent.

✓ ✓

Charles A. Fisher has been appointed assistant to the president of the Jones & Laughlin Steel Company, Pittsburgh.

✓ ✓

Dr. Sidney R. McCurdy, formerly chief surgeon of the Youngstown Sheet and Tube Company, is now with the Eighteenth Infantry in France and has been cited for bravery.

✓ ✓

Russell Gangewere has been elected president of the Weatherly Steel Company, Weatherly, Pa., which recently acquired the Weatherly Iron and Steel Company.

✓ ✓

J. C. Agnew has been appointed assistant to A. C. Dinkey, president of the Midvale Steel and Ordinance Company. He was formerly general superintendent of the Mahoning Ore & Steel Co.

✓ ✓

J. Rogers Holcomb and Roger B. Farquhar have become president and vice president, respectively of the Electric Steel Company at Indiana. Both Mr. Holcomb and Mr. Farquhar were formerly associated with the Midvale Steel Company.

✓ ✓

L. J. Campbell, vice president of the Youngstown Sheet & Tube Co., Youngstown, Ohio, who has been serving as manager of the Three-hundred and Ninth Field Artillery in France, has been appointed to lieutenant-colonelcy.

✓ ✓

Garret A. Connors, Jr., foreman of the Truscon Steel Company, has been appointed director of safety.

✓ ✓

M. L. McGraw, formerly superintendent of the Lakeside Foundries, Detroit, has been appointed general superintendent of the Gray Foundries, Inc., Poultney, Vermont.

J. Frank King has accepted a position as assistant to Warren F. Perry, industrial engineer of the Brier Hill Steel Company.

✓ ✓

H. A. Andresen has resigned his position as district examiner for the Emergency Fleet Corporation. His headquarters were at St. Louis, Mo.

✓ ✓

H. E. Fields, president of the Wheeling Mold and Foundry Company, Wheeling, W. Va., is now director of the chemical division of the War Industries Board.

✓ ✓

E. L. Garrihan, has recently become sales manager of the Tioga Steel and Iron Company. He was formerly connected with the manufacturing and sales department of the Bethlehem Steel Company.

✓ ✓

John Drewson is now superintendent of the new coke plant of the Jones and Laughlin Steel Company, Hazelwood, Pa. Mr. Drewson was formerly superintendent of operations at the McKinney Steel Company's coke plant at Cleveland.

✓ ✓

J. F. Curley, formerly connected with the Thurlow Steel Company, Chester, Pa., and more recently with the Canadian Steel Foundries, Ltd., is now assistant works manager of the Pittsburgh Iron & Steel Foundries Co., Midland, Pa.

✓ ✓

I. H. Mills, who has been associated with the Westinghouse Electric & Manufacturing Company, of East Pittsburgh, Pa., for the past twenty-three years, has resigned to become superintendent of the Sperry Gyroscope Company of Brooklyn, N. Y. Mr. Mills began his career with the Westinghouse as a machine operator, and finally became superintendent of the small industrial motor department.

✓ ✓

Mr. J. E. N. Olsen has been appointed local auditor by the Sligo Iron & Steel Co. of Connellsville, Pa. Mr. Olsen has been connected with the Republic Iron & Steel Co. since its organization, and for the past four years has been local auditor at the Moline works.

✓ ✓

G. A. Binz, sales manager, Yarnell-Waring Company, Philadelphia, has transferred his headquarters to the company's New York office at 90 West street, and will in future devote his whole time to the interest of "Yarway" specialties in that area.

WITH THE EQUIPMENT MANUFACTURERS

PULVERIZED FUEL EQUIPMENT.

The question of burning pulverized coal as a fuel is being thoroughly investigated. During the past year some very interesting experiments have been made and among the different problems is the one of pulverizing.

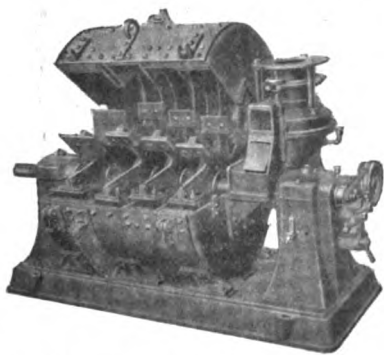


Fig. 1--View of Pulverizer when open

We are presenting herewith a type of pulverizer that has proven very efficient and is being used at the present time with a great deal of success. Figure 1 shows the pulverizer while Figure 2 shows the layout of equipment. Artificial drying of the coal is purely optional when using this equipment because the effect of moisture is reduced to its lowest point. No storage is necessary since the coal is burned as fast as it is pulverized. In that way the hazard of fire and explosion is eliminated. Practically any grade of coal can be used if it contains 25 per cent or more of combustible matter.

Because of the elimination of extra machinery or equipment the matter of labor is reduced and practically eliminated. The pulverizer runs at a constant speed and the operator's attention is limited to observation of his fire and the regulation of the feed mechanism and dampers. It is

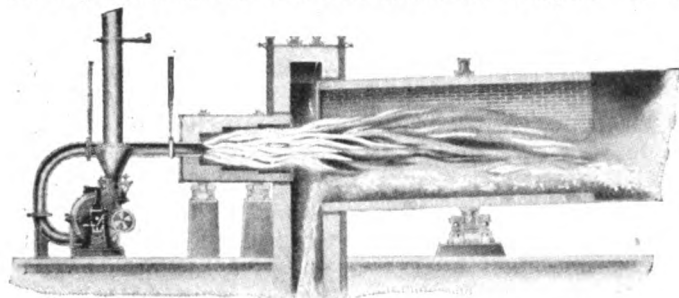


Fig. 2—View showing how the system works.

possible and practical to have one operator take care of a number of pulverizers. The machine is dust proof and built so that repair can be made without much trouble.

The pulverizer is manufactured by the Aero-Pulverizer Company, 120 Broadway, New York, N. Y.

UNDERFEED FIRING.

It is claimed by plants using underfeed stokers that they have reduced the cost of operation in the power house 15 to 25 per cent. The principle involved in underfeed firing is interesting to anyone burning coal. The final result of complete combustion of ordinary coal, in general, is CO_2 . The percentage in the flue gases is a guide to the efficiency of the furnace. This can be determined by proper instruments, or by observing the amount of black smoke coming out of the stack, or the amount of carbon in the ash. Coal in the ash pit and black smoke indicates faulty combustion. One cause is that fresh coal if shoveled directly into the furnace is literally "too green to burn." In other words, if the coal

is heated not enough to distill the volatile matter before it enters the incandescent fuel bed itself; when it does enter, combustion is immediate and perfect. There is no smoke and little carbon lost. Fifteen per cent CO_2 is easily obtained instead of 6 per cent common to improper combustion.

The underfeed stoker in the illustration shows clearly the manner of getting "hot" coal into the fire from below. Fresh coal is introduced into the hopper and is forced by cylindrical rams into retorts that underlie the fuel bed. The retorts resemble troughs which are inclined from the hopper down and across the furnace. These multiple retorts are separated by rows of tuyeres that support the burning coal and furnish air to the fire. The rams fill these troughs full and then continue to force more in. This crowds the coal already in the troughs up and onto the tuyeres where combustion is completed. However, during the time that the coal remains in the troughs, that is, before it is forced up, it reaches such a temperature that distillation has taken place. Hence it is in perfect condition for complete combustion.

The underfeed stokers are equipped with an auxiliary forced draft system that insures the correct amount of air for perfect combustion. They can be handled by less firemen, thus releasing labor to other parts of a factory. They are adapted to many kinds of coal and have a wide range of flexibility so desirable where high peak loads are necessary at certain periods of the day.

IMPULSE GAPS FOR LIGHTNING ARRESTERS.

Impulse gaps for lightning arresters are recommended for use in connection with lightning arresters which protect stations of large capacity operating at 11,000 volts and higher. The impulse gap excels every other known gap in assisting arresters to give protection from lightning and other high-frequency or high-voltage disturbances.

The impulse gaps, as listed herein, are for use in connection with electrolytic or other three-phase (grounded or ungrounded-neutral-circuit) lightning arresters now in service.

The Westinghouse impulse gap protects the insulation against high-frequency or sweep wave-front surges of high potential at a lower voltage than does any other known gap.

Operation—The old-fashioned plain horn gaps had considerable time-lag, allowing a high-frequency surge to rise to a much higher voltage than would a low-frequency surge before discharging and giving protection. The development of the sphere gap partly prevents this situation by eliminating the time lag so that all frequencies are discharged at the same voltage. The new impulse gap has a negative time lag; that is, the higher the frequency the lower the voltage at which the gap discharges. Thus the impulse gap automatically selects the dangerous surges and gives protection more quickly than any other known form of gap.

The impulse gap not only incorporates all of the virtues of the horn gap and the high-speed sphere gap, but also possesses the property of selecting high-frequency or steep-wave-front surges and discharging them at a lower voltage than the normal voltage setting of the gap. It should be particularly noted that the impulse gap is the only device which will protect insulation against a steep-wave-front surge of reverse potential, that is, a sudden drop in voltage. The high-frequency discharge voltage may be as low as two-

WITH THE EQUIPMENT MANUFACTURERS

thirds, or even one-third, of the normal-frequency value. It is, therefore, possible to use a gap setting that will permit of the desired degree of protection against dangerous surges while not permitting too frequent discharging on minor surges at normal frequency.

The high speed of the sphere gap as compared with the horn gap is due to the elimination of the time required to build up a sphere of equal-potential surface at the discharge part of the horn gap. The sphere of equal potential surface and practically eliminates corona and reduces field distortions when the gap is set equal to, or less than, the sphere diameter. By the use of the sphere gap the voltage to ground, or the breakdown voltage, at any frequency does not materially exceed the 60-cycle discharge voltage of the gap. However, the sphere gap does not give the desired protection against steep-wave-front, or high-frequency surges, due to its inability to discharge these disturbances at lower voltage than the normal frequency setting of the gap. It is necessary to set all arrester gaps for a sufficiently high normal frequency setting of the gap can be had without the corresponding disadvantage of reduced protection, since the high-frequency breakdown-value of the gap is much lower. This is because high-frequency discharges start from the auxiliary electrode and have only one-half of the gap to jump. The latter electrode, also, is so shaped that although the gap is one-half of the main gap, the break-down voltage is only about one-fourth as great: that is to say, high-frequency surges not only delayed in discharging, as with plain horns, by the need of building up a static field; but instead, discharge at a voltage even lower than the normal value of the main gap, since they automatically select the auxiliary gap of much lower voltage breakdown.

EXPORT AMALGAMATION.

The W. J. Crouch Company, Inc., and Rownson, Drew & Clydesdale, Inc., announce the amalgamation of their respective organizations. All trading and manufacturing operations henceforth will be conducted under the name of Rownson, Drew & Clydesdale, Inc., with general offices at 68 William street, New York.

In future, the name of "Crouch Steel" and all that it implies, will be linked with the century-old traditions of the house of Rownson, Drew & Clydesdale, which should be a guarantee to their customers all over the world, of the highest in service.

P. G. Donald, president of Rownson, Drew & Clydesdale, Inc., will continue in this office, while Mr. I. Smullyan, president of the W. J. Crouch Company, Inc., will act as managing director of the new firm.

Messrs. Victor E. Karminski and A. E. Hearne, both treasurer and general manager of the W. J. Crouch Company, Inc., and Rownson, Drew & Clydesdale, Inc., respectively, will in future act as joint general managers of the new concern, Mr. Karminski conducting the Crouch steel division, and Mr. Hearne directing all other trading operations.

Elaborate plans have been made for the further development and expansion of the Rownson, Drew & Clydesdale engineering division in order to cope with the wholly unprecedented demand for their gravity runways, portable elevator conveyors and other labor saving devices. These plans will be carried out under

the personal direction of John J. Smart, secretary and assistant general manager of the W. J. Crouch Company, incorporated.

A vigorous advertising campaign will be undertaken by the new firm, embracing both Crouch steel products and Rownson, Drew & Clydesdale specialties. This campaign will be carried into all foreign countries, as well as into every state of the union, and will be directed in all its branches by M. Oppenshaw, who has hitherto had charge of the advertising for the W. J. Crouch Company, incorporated.

H. Lad Landau, assistant secretary and general manager of sales of the W. J. Crouch Company, who is perhaps best known to the numerous friends of the firm in all parts of the world and to whose untiring efforts much of the success of the W. J. Crouch Company, Inc., is due, will continue with the new concern. So will other leading officers of the company, such as John H. Allen, purchasing agent, who will in the future be assisted by M. Greenberg, of Rownson, Drew & Clydesdale, Inc., Albert Smullyan, comptroller, O. W. Andrews, traffic manager and head of the company's licensing bureau, and all others occupying positions of trust with the old companies.

A TRACKLESS TRAILER WITH DUMP CAR BODY.

The increasing use of industrial tractors has created an unusual demand for all kinds of trailers. To meet the demand for a car that would not only admit of easy trailing but would also speed up loading and unloading of loose materials the new Easton car was developed.

It is a four-wheel steer trailer that will run over cement, wood, composition or any kind of flooring. In fact it will even run quite smoothly over rough ground when supplied with extra large wheels. All wheels are equipped with roller bearings and may be furnished with rubber or composition tires.

Close tracking of trains of these cars is accomplished with comparative ease because both front and rear trucks of each trailer swivel. Trains of six cars will track within three inches and will take a curve of 8 ft. radius, or smaller.

The body of the trailer is distinctive and possesses many features that make for economy and speed in loading and unloading coal, ashes, sand, ore, slag, refuse and practically every kind of bulk material. Some of the more important features include: Special latch for locking the body in a half-dumped position, thus lowering the loading height for hand loading. Automatic safety latches. Extra heavy body that dumps clear of the wheels, the only type that will so dump (45° angle of dump). Cast steel rockers and extra heavy underframes. The car is built by the Easton Car & Construction Company, of Easton, Pa., who lay claim to a highly standardized line of cars and equipment for every industrial service.

NEW REFRACTORY BULLETIN.

The Quigley Furnace Specialties Company, New York, has just published a small folder describing "Insulbrix." The following characteristics of the refractory brick are discussed: Thermal conductivity, heat resisting qualities, crushing strength, tensile strength, surface and structure, permeability and salvage value. The folder further states that information and samples of this brick will gladly be submitted by the Quigley Furnace Specialty Company, upon receipt of request.

Trade Notes

All storage restrictions on bituminous coal were removed November 22 by the United States Fuel Administration in conformity to the action of the War Industries Board in cancelling its preferential industries list. Anthracite coal is not affected, however, by the ruling of the Fuel Administration. Every industry and every householder in the country now may store as much bituminous coal as desired or obtainable, as the action of the War Industries Board removes the necessity for the Fuel Administration to distinguish longer among different classes of industrial plants. The restrictions just raised provided for the accumulation by the consumers in the preference classes defined by the War Industries Board, of reserve stocks of bituminous coal, in accordance with their location in relation to various mine fields and their classification on the preference schedule. All industries located farthest from distribution points, particularly those in New England and in the northwest are found not only to be well stocked, in accordance with Fuel Administration specifications, but in many cases have surpluses above those amounts.

The Shephard Electric Crane & Hoist Co. has opened an office in the new Lexington Building, Baltimore, Md., in order to take care of the rapidly increasing Southern business and also to give closer service to users of Shepard apparatus in that territory. This office will be in charge of Mr. Norman P. Farrar, who for a number of years has been district manager of the Philadelphia territory.

Announcement is made by the C. O. Bartlett & Snow Co., 1040 French street, Cleveland, that it has been found necessary to close its eastern branch at 50 Church street, New York City. All communications should be sent to the company's main office in Cleveland. H. H. Bighouse, second vice president and chief engineer, who has had charge of the New York office, now is located at Cleveland.

The Heating & Power Equipment Co., Milwaukee, has changed its name to the Sterling Engineering Company, and has increased its capitalization from \$15,000 to \$50,000.

The West Allis Scrap Iron & Metal Co., West Allis, Wis., has changed its corporate style to West Allis Iron & Steel Co. The capital stock has been increased from \$5,000 to \$10,000.

The Booth-Hall Company, manufacturers of electric furnaces, 2309-15 Archer avenue, Chicago, Illinois, have placed in successful operation during the past few months, the following steel melting furnaces: West Michigan Steel Foundry Company, Muskegon, Mich., 3-ton basic castings for naval gun carriages. Monroe Steel Castings Company, Monroe, Mich., 1½-ton acid steel castings. Queen City Foundry Company, Denver, Col., ¾-ton

basic steel castings for emergency fleet corporation. New England Steel Castings Company, East Longmeadow, Mass., 1½-ton acid steel castings. In addition to these furnaces, there is also a ¾-ton acid lined furnace in operation at the plant of the Duriron Castings Company, Dayton, Ohio, used for experimental work in the manufacture of duriron and a 1½-ton furnace at the Avery plant, Peoria, Illinois, basic, used for the manufacture of tractor castings.

The Ford-Smith Machine Company, Hamilton, Ont., has removed from Earl and Princess streets to its new headquarters on Cavell avenue. While a part of the plant is to be ready this week, the entire plant will be in operation in about one month.

The Maryland Bolt Company, Continental Trust Building, Baltimore, has changed its name to the Maryland Bolt & Forge Co.

Trade Publications

Leather Belting—The Graton & Knight Manufacturing Co., Worcester, Mass., has just issued a booklet devoted to standardized leather belting. The booklet contains much interesting information about leather belts and includes several tables and standards for belts that the company has worked out from many years of practical experimentation.

Safety Goggles—A well illustrated 24-page catalog, entitled "Save Your Workmen's Eyes," has been issued by the Julius King Optical Company, New York. A large assortment of goggles adapted to practically all industrial operations where the eyes are in danger is shown. In the construction of these goggles, the lenses receive special attention and all goggles manufactured are provided with surface-ground lenses which are clear, bright and of great transparency. Furthermore, it is claimed that these lenses will not splinter when broken. Among the goggles shown are those equipped with different types of side frames, particularly recommended for workers engaged in chipping or chiseling in metal and breaking or drilling brick or stone. Various types of welders goggles are illustrated as well as respirators, welders, helmets, face masks, babbiting masks, etc.

Circulating Pumps—The Fulflo Pump Company, Blanchester, Ohio, recently issued a circular describing its circulating pump which is used in connection with machine tools, grinders, etc., for supplying cutting and cooling compounds. It is pointed out that the construction of the pump is such that it is impossible for it to lose its prime and that chips can be run through it without injury to the working parts. The pump works on the centrifugal principle and may be mounted either above or below the level of the liquid to be delivered. The only working part of the pump is the impeller which is mounted directly on the drive shaft. The circular de-

scribes the pump fully and contains several illustrations showing its mechanical details.

Attaching Devices—A small 4-page folder in which 21 of the various electrical attaching devices manufactured by the Cutler-Hammer Manufacturing Company, Milwaukee, is described and illustrated, is being circulated. They include numerous types of flush, surface conduit and metal mounting receptacles besides motor attachment plugs, cord connectors and current taps. These devices have a rating of 10 amperes, 250 volts, with the exception of the attachment plug and current taps, which have the maximum screw shell or socket rating of 660 watts. The folder lists the complete line of devices.

Belt Conveyors—Jeffrey Manufacturing Company, Columbus, Ohio, Catalog No. 175. Deals with the development and use of belt conveyors for handling a great variety of material special reference of course being made to the company's products. Drawings and typical examples of conveyors are presented together with a list of the industries in which they are used and the materials handled. The various forms of pulleys and belts that can be supplied are illustrated and briefly described with condensed specification and dimension tables. A number of views of the conveyors in use are also presented.

Coal and Ash Handling—The Link-Belt Company, of Chicago, has issued book No. 353, "Economical Handling of Coal and Ashes and Reserve Coal Storage."

Obituary

Harold Tupper, assistant superintendent of the Ella Furnace Company, West Middlesex, Pa., died November 2, at the age of 26, at his home in Sharon, Pa.

Alfred R. Jones, president of the Pusey & Jones Company, died of pneumonia at Wilmington, Delaware.

James Douglass, for the past 10 years general furnace foreman at the Lucy plant of the Carnegie Steel Company, died in Pittsburgh, November 28.

Williard E. Case, a prominent electrochemist, who conducted numerous researches, died at his home at Auburn, New York, August 27.

Edward J. Hamilton, general superintendent of the Duquesne works of the Carnegie Steel Company, died October 23, of pneumonia. Mr. Hamilton became superintendent of the Duquesne works in 1915, when Homer D. Williams became president of the Carnegie Steel Company.

Sidney F. Oliphant, former owner of the Oliphant Steel and Iron Company, died at his home in Trenton, N. J.

Thomas John Davey, one of the eight brothers who operate the Mansfield Sheet and Tin Plate Company, died of pneumonia, October 17.

The Blast Furnace *and* Steel Plant

Pittsburgh, December, 1918.

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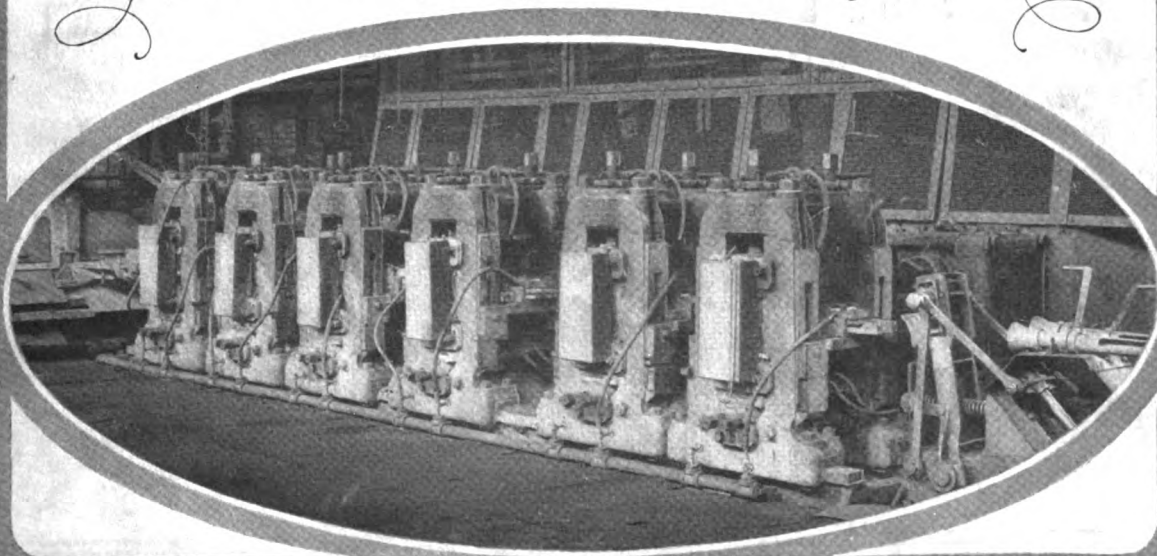
80 in the
United States
of America

5 in Canada
5 in England
4 in Germany
3 in India

1 in France
1 in Belgium
1 in Austria
1 in Australia

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